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HARRY E. JORDAN
PRESIDENT, 1934–1935

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UP-TO-THE-MINUTE EQUIPMENT FOR CUSTOMER ACCOUNTING[1]

This paper is not intended to be a treatise on the fundamental principles of accounting or the mechanics used therefor. The field of public utility accounting is so vast and varied that in most cases the accounting methods and equipment are selected for particular needs. There are many divisions of utility accounting, among them being the following: customer, payroll, material and supplies, accounts payable, accounts receivable, general records, reporting record, statistical accounting and other divisions which may be found advisable or desirable as the case may be.

Our studies of equipment used in the accounting division of utility offices has been limited to that line of equipment particularly adapted for and used in customer accounting. Studies have been made and information gathered from many sources including both large and small plants, municipally and privately owned, plants having large numbers of customers as well as the smaller plants which furnish but a few thousands. In our investigations, we found a number of cases where the accounting of the water works plant was combined with

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that of accounting for other utilities; such as, electric power and light, sewage, and in some cases gas plants. There is apparently no difference in the adaptation of accounting equipment to the needs of any particular line of public service, the only problem being that of preservation of records and furnishing the customer with an intelligent statement for the service rendered him.

DIVISIONS OF CUSTOMER ACCOUNTING

An analysis of the term "customer accounting" shows that it can be properly divided into four headings or divisions each of which represents a unit in itself and must be considered separately as an integral part of the entire subject. For the purpose of this paper, we have made the following divisions and will attempt to set out the results of our studies accordingly:

Meter Reading
Billing and Records
Cash Posting
Collection

METER READING

Under the heading of meter readings, we will take up the question of meters and their locations. At first thought, many would not appreciate the fact that a meter is a very important part of the equipment for customer accounting. The passing of the old flat rate or assessment system has brought the meter or measurement system squarely before us. Its use has demonstrated beyond any doubt that it is the most practicable, fair, and efficient method of selling public service. The meters must be serviced and kept in good condition. Dirty meters and those with loose hands are conducive to incorrect readings, loss of revenue, or customer friction; and if improperly located, more time may be lost in getting to the meter or in procuring the reading than would be necessary under proper conditions. In the furnishing of water, gas, or electric service, there is a continuous but varying percentage of high consumptions. Every reading reported on which there is a consumption shown higher than the usual is a potential complaint as well as a possible error which may or may not disrupt the accounting work.

Apparently when the use of water meters was in its infancy, there was not enough thought given to the intelligent inspection of such cases or any provision made for the elimination of complaints from

this source. Formerly, it was common practice to employ students, young or old men, or almost anyone who could walk and carry a pencil and paper, to read meters. If the customer complained on the consumption as shown by the bill, another man was sent out to check the reading. When this was done, the customer was seldom notified of the result of the check and the company considered it had rendered its full service. This viewpoint has now been changed, primarily for two reasons: First, from the standpoint of public relations and improvement of service; and second, from the standpoint of accounting. The meter reader is no longer regarded as one who merely puts down on paper the reading of the meter. He is the continual contact man between the utility and its customers, because it is his service, his attitude, and his explanations to the customers, which makes either a satisfied community or otherwise.

Qualifications for meter readers vary considerably. We find that the meter reader is becoming a very important person in the life of the utility and also a very material factor in the accounting division. One utility in this state requires that its meter readers must have a minimum of education amounting to completion of a high school course. They must pass a rigid physical examination before being employed and their service is continued only so long as their physical conditions and proper conduct measure up to high standard.

In the days when students and other temporary help were employed as meter readers, there were many incorrect readings discovered. In order to correct this situation, many utilities adopted the plan of furnishing their meter readers with monthly route books not giving the previous reading of the meter. It was thought that this method would compel the meter reader to visit the home and accurately record the reading of the meter. The plan worked in theory, but was not entirely successful, because of ever-changing personnel and lack of training of the men. With the raising of the standard of qualifications of meter readers, the accuracy of the meter reading was improved, until at the present time in well operated plants with the proper supervision, the number of incorrect readings has been reduced to a minimum.

In the large majority of the cases now, the utility furnishes its meter readers with a route book made up for periods from 2 to 6 years in which book all readings, reading dates, and consumptions are recorded. To the intelligent reader or inspector this route book with its information is as necessary and valuable as the ledger accounts are to the accountant.

Record is made in the route book of those cases where the meter reader is unable to procure a reading and the reason given, and it is fast becoming a practice of the larger plants either to average the bill according to the past consumptions in these cases or to render a bill for the minimum charge covering the billing period, only attempting to pick up these readings when they have been missed for a certain period of months or quarters. This method is found almost universally acceptable to the customer and is the most efficient way of handling the account from the standpoint of office procedure.

The efficiency of the meter readers and inspectors will be increased or lessened according to the importance given to their position and the equipment furnished them for the performance of their work. A large business concern could not afford to send salesmen into the field to represent it who lacked sufficient education, tact, and training, who were untidy in dress and personal habits, or who did not have the proper equipment to maintain the dignity of their position and take care of the company's interest in the best manner possible. The requirement of neat and proper fitting uniforms for meter readers and equipment; such as, flash lights, pliers, screw drivers, and other equipment necessary for their use is an investment many times repaid in increased efficiency in their work and in the public relations of the company.

BILLING AND RECORDS

We now come to the point of customer billing, accounting, and office records. Originally bills for utility service were made out in longhand and records kept in bulky and cumbersome ledgers. The bills as well as the records were not always neat or legible due to the different styles of handwriting. It was also found that in most plants municipally operated the records were often not complete due to the changing of clerical help with the change of administration in power.

Within the last twenty-five years, there has been a marked change both in the attitude of utility managers and the customer toward a more efficient operation of plants and service to the consumer. The demand for more efficient methods in billing, proper keeping of records, and efficient service to consumers opened a wide field for the manufacturers of mechanical equipment to meet the situation. New forms of bills were designed, each with the idea of covering the particular demand of the company interested. Some of the bills

were made in long paper form, some used the regulation 1 cent government post card, while others combined the advantages of the paper bill with those of the government post card stock, making the original bill with one or more stubs of indeterminate length; and by retaining the government regulation on the width of the bill form, when the bill was completed, the part going to the customer was cut off in post card size conforming to the government regulation and mailed under 1 cent postage.

At the same time, there were many forms of record systems set up in order to keep an accurate record of transactions between the utility and the customer. The more widely used of these record or ledger systems are: the old "Boston Ledger" or the hand posting system, the loose leaf system, bill and register sheet or register sheet system, visible card or record system, and the stub system. All of the above mentioned systems with the exception of the Boston Ledger lend themselves to mechanical accounting. The controlling factors or requisites for any customer accounting, record, or billing system are practically the same. First, there must be neatness of the bill sent to the customer together with the neatness of office record; second, absolute accuracy of the bill and records; third, speed, this requisite being given considerable attention in the larger plants where it is necessary to send out thousands of bills daily and where the volume of office work in connection with the sending out of these bills demands the highest point of efficiency in order to keep down overhead costs on this work; fourth, the control of all billing work and records is the governor which keeps neatness, accuracy, and speed in proper co-ordination.

In designing bills for utility service, two important facts must always be kept in mind. The first of these, the customer requirements, and the second, the company requirements. The customer's first interest is the amount of the bill and what he is required to pay. It is doubtful if more than ten percent of the consumers receiving a bill ever look beyond that portion showing the dollars and cents that the company asks them to pay for the service rendered. If the amount of the bill is in the usual place and is about the same as they have always paid, no further attention is given to what is written or printed on the body of the bill. It is taken for granted that the bill has been correctly made and the charge is correct. It is in the remaining cases that sufficient detailed information must be given to enable the consumer to intelligently calculate to his own satisfaction

the accuracy of the bill received. The dates of meter readings, the reading of the meters at the different dates, consumption of water, gas, or electric current, as the case may be, the final payment date, and the rate at which the consumption has been actually charged are necessary for the consumers' guidance.

All of this information formerly was placed on the bills in a laborious, manual method, but thanks to science and inventive genius, few if any of the old manual systems now survive. There are many bookkeeping and billing machines on the market today which have been tried under the most varying conditions imaginable that will take care of any demand of customer or company in the matter of billing or record work. In those cases where it is desirable to keep a ledger or register sheet of each account showing the detailed data by months, such as dates of reading, meter readings, consumption, amount of bill, and date of payment therefore, automatic machines have been designed which record this information at one operation; either the bill or the register sheet may be made as the original according to the desires of the operator.

In the case of stub accounting system where the original bill is made together with a cashier's stub and an accounting stub, the register sheet is placed beneath the carbon under the bill, and the exact data placed on the bill is recorded on this register sheet. These register sheets are then used for control and balancing purposes and are filed away as records for such time as may be desired. Under the stub system of billing, permanent record is kept in meter readers' route books of meter readings, dates, consumptions, and charges, and these books are kept as permanent records and are accessible at all times when needed.

The operation of the automatic billing machines is very simple. Anyone who can operate an adding machine can readily learn to operate the billing machine. The accuracy and speed of the operator depends entirely upon practice. The automatic billing machine is almost unlimited in the information it produces. We will not go into the mechanical perfection of these machines, but will leave that to the salesman. It is sufficient to say that all information desired; such as, date of bill, date of reading, meter readings both present and past, consumption, amount, arrears, credits, and merchandise sales can be placed on the bill with these machines, and the perfect bill, neat and absolutely accurate, is made automatically and without manual labor.

In those cases where there is a flat rate or an assessment for service and the charge is not made according to meter measurement, there is a decided advantage in rendering a printed bill. These bills may be printed by job printers or printed by the utility by the use of specially constructed machines. If this printing work is to be done in the utility office, records of the account are kept on plates. These plates are filed numerically and bills are printed from them at regular periods conforming to the billing system. The latest development in this line is a machine which takes a roll of blank paper of any desired thickness, prints the bill in its entirety on both sides together with the customer's name, address, account number, and any other information desired, cuts the bill to the proper length, and delivers it complete and stacked according to the proper rotation. This machine has been found very efficient in the handling of a large volume of bills, especially in those cases of continuous daily billing. There is a dating device on this machine which may be changed daily, thus preparing the bill for daily use if it is used in connection with other billing equipment.

An addressing machine of some kind is now considered essential in all utility offices. These machines are designed to take care of the needs of both large and small plants at a minimum cost of operation. The use of addressing machines is not limited to addressing bills and statements but is very practical in heading up ledger sheets, meter reading route books, payroll listing, checks and mailing lists, and many other operations. In most cases it is advisable and economical to purchase with the addressing machines, plates and equipment for making changes of names, addresses and account numbers because this is a continuous job in every utility office.

It was formerly necessary to deliver utility bills by hand or purchase postage stamps and affix them to the bills for mailing. The delivery of bills by utility employees or delivery companies has not been found satisfactory in all cases. Recent post office rulings in regard to leaving utility bills in mail boxes and prohibiting the delivery of mailable matter by distributing companies has interfered with this manner of sending bills. The work of affixing stamps to bills for utility service is necessarily tedious and sometimes costly. It is not always possible to account for large supplies of postage stamps where the method of affixing stamps to bills is used. Damaged stamps, petty pilfering, and unauthorized use of postage stamps by employees and others are some of the evils of this system.

Post office rules and regulations have been made sufficiently flexible to allow the use of permit printers and postage meter machines. In the use of this form of postage, the Post Office Department requires an advance deposit to cover the mailings. This may be handled in one of three different ways. In the case of the postage meter or register, the apparatus is taken to the Post Office, the mechanism set for a certain number of mailings and the Post Office receives pay at that time for the number of mailings for which the machine has been set. The second method which may be employed is the postage printer, the use of a canceling machine, which prints a facsimile of the government indicia showing the date of mailing, post office, and the amount of the postage together with the permit number. This machine records the number of mailings passed through it by a register which is under control of the operator. These mailings are delivered to the local Post Office together with a remittance covering the full amount of the mailings as recorded by the machine register, or the company may estimate the amount of postage to be used for a period of time and deposit with the Post Office Department this amount of money, and when the mailings are delivered daily or at other regular intervals, the amount of postage will be charged against this advance postage account. The Post Office Department in order to guard against fraud on the part of the mailer checks the mailing statement by the weight and ratio method. This method of handling utility bills is a convenience and saving to the company as well as convenience to the Post Office Department. There is no chance for losses through the sources mentioned before. The third plan of handling the bills which is allowed by the Post Office rules and regulations is that of having the permit number and other required data printed on the bill or envelope used according to Post Office regulations. The method of paying for postage under this system is similar to the one just explained and may be found very satisfactory in those cases where bills are mailed in envelopes.

CASH REGISTERS AND CASH POSTING

The Cashier's Departments or receiving tellers are important factors in customer accounting, second in importance only to the meter readers. The majority of customer contacts with the utility are through the meter readers and payment of bills. Formerly, it was the custom for large numbers of people to pay their utility bills by check, but bank failures in the last few years together with the check

tax imposed by the federal government has caused many customers to come to the utility office and pay their bills in cash. The handling of the bill in the Cashier's Department when it is presented for payment must be speedy and accurate. The old method of stamping a bill "paid" with a rubber stamp and counting change from a money drawer is about out of the picture. Even the smallest utility office can now afford a cash register and a money changing machine. The cash registers now used in utility offices are built to suit the individual needs of each company, the requirements of these machines being in most cases a recording of the amount of the bill, proper cutting off of the cashier's stub, keeping a tape record of the operator, date, serial number of the payment, and the amount recorded by the register. The totaling mechanism of the machine shows the amount of cash taken in during the day. These machines are electrically operated and require no previous experience or training on the part of the cashier.

Automatic money changers are regarded as a necessity now in offices where large numbers of payments are received daily. When the human element is depended upon for accuracy, there must be an allowance made for errors, but the money changers are not liable to such mistakes. They are mechanically correct. Their use gives the cashier accuracy, speed, and sufficient time to say "Good Morning" and a pleasant word to the customer.

Other necessary mechanical equipment for the cash receiving departments are electrically operated adding machines, check canceling machines, letter openers, and in those companies where it is the duty of the treasurer or cashier to sign checks, special machines for this work are provided eliminating the longhand signatures, which sometimes took several hours daily of a high salaried official's time.

There is apparently no mechanical device today which will sort the cashier's stubs as received by the Cashier's Department to their numerical sequence and make them ready for the cash posting department. The sorting and listing of these stubs is a manual job which can be made less tiresome and monotonous by the use of electrically operated adding machines.

The next step in the cycle of customer accounting is the posting of the cash receipts to the customers' accounts, thus closing the cycle in those cases where the meter has been read, bill rendered, and paid according to the regular routine. This work along with the bookkeeping and billing has seen many changes for the better. Formerly

a record was made in longhand of the amount paid by the customer, the date, and if it was paid by check, check number, and the bank on which it was drawn were also recorded. This method finally gave way to the rubber stamp whereby the date was placed on the customer's account showing the date that the full amount of the bill was paid. With the advent of the bill and register sheet method of bookkeeping and billing, payments were recorded by the cash posting machine which posted the amount paid together with the date, and at the same time carried an accumulating total of cash received. At the end of the posting, the machine total was compared with that of the cash register operated by the receiving tellers the previous day and the accounts were balanced accordingly.

In the stub system of accounting, the cash posting has become more simplified; instead of having a ledger, the customers' accounts are kept on stubs. These may be kept in drawers, in trays, or on stub stands. When an account is paid, the cashier's stub from the receiving teller's department is merely matched against the stub in the bookkeeper's file and if the amount is paid in full, the file stub is then withdrawn, matched up with the cashier's stub, and laid aside, leaving only the unpaid stubs in the bookkeeper's file. Balances may be secured by two methods under this system; first, by adding the paid stubs as taken out by the bookkeeping department and comparing them with the report of the receiving tellers or cashiers for the previous day, or the stub stands or files of unpaid accounts may be totaled daily and to this total the amount of receipts as shown by the cashiers or receiving tellers added, which will automatically balance with the total in the stand before the posting.

The stub system of accounting is designed for speed and accuracy in those companies handling a large number of daily payments. The mechanics of the work are simple and control absolute.

COLLECTIONS

This part of the subject is of the utmost interest to every utility operator in these days. Whatever has been the custom in the past has been radically changed in the last two or three years because of the unemployment situation and apparent growing tendency of certain classes of customers to evade or postpone payment of bills under the alibi of "depression." Investigations have shown that the methods employed by utility operators in the collection of bills vary considerably. It is an unfortunate fact that some utilities have almost

declared a moratorium on the collection of old bills and are content with their endeavors to collect current accounts. Others have endeavored through different ways and methods to collect current accounts and at the same time a portion of the old accounts each month or quarter. Some of the smaller municipal plants have even gone so far as to allow delinquent consumers who are many months delinquent and out of employment and funds to work out their water bills, performing such maintenance work as is available and for which the Company might otherwise have to employ labor.

All these different plans have upset more or less any pre-arranged or orderly collection routine, and any plan which might be set out for one utility might not be found practicable in others. Therefore, this question will be considered from the standpoint of the mechanics of routine collection and the use of such mechanical equipment as has been found adaptable for the usual cases. For this purpose, accounts to be collected are divided into three divisions:

Current Bills
Delinquent Bills
Final Bills

Under the heading of current bills are those cases where the meter is read regularly every month or at other stated intervals and the bill sent out is to be paid within a certain period of time. This division probably covers 75 to 80 percent of all bills sent out, and the payment period allowed on current bills is usually from 10 to 30 days. In the majority of cases, there is no follow up on the current bill unless the Collection Department has inside information that there is a possibility of the customer leaving the city, or in the case of Commercial and Industrial accounts, pending receivership or bankruptcy actions. The usual treatment of such cases is a telephone call or personal call by the collector or investigator, endeavoring in a quiet, unobtrusive way to get payment of the account before the expiration date.

The second class of bills known as delinquents are the real trouble makers. Delinquent bills may be divided into two classes: Those not paid because of the financial circumstances of the consumer, and those not paid because of the consumer's habitual delinquency. In making up and sending out delinquent bills and notices, three methods are employed: first, the making up in longhand or on typewriter, a delinquent notice either on post card or regular bill form and mailing it to the consumer. Second, some companies make up a

second bill or copy of the original bill at the time the original is made and this is used as the delinquent reminder or notice. Third, a special delinquent notice together with a last notice and disconnect or turn off order is made on all delinquent accounts. These three orders are made on a manifold copy by a specially constructed typewriter, the first or delinquent notice being the original copy and the last notice and disconnect order being carbon copies, properly worded and set up so that the information typed on the delinquent notice fills in all necessary information on the carbon copies below. When the delinquent notice is mailed to the customer, the last notice and disconnect order are filed under a future date. When that date arrives, the customer's account is checked, and if it is paid, both the last notice and the disconnect order are destroyed. If unpaid, the "last notice" is mailed to the customer and the disconnect order is filed under another future date. When that date arrives, the second check up is made of the customer's account, and if it is still unpaid, the disconnect order is sent out with instructions to turn off the service. This system works perfectly when followed under close supervision. Special attention can be given to any account at any time in the handling of these manifold orders by withdrawal of the tickets and setting them up for future reference in a date file.

At this point, there may be mentioned a new idea which may eliminate the purchase of the carbon and the threading of the multiform delinquent notices. The new idea is a multiple pre-carbon stuffed form under the name of "Rediform Speediset." This form can be made in any number of carbons up to 13 and a fine grade of carbon paper is set between each copy by the manufacturers. This carbon is to be used only once and the Speediset has the advantage of being adaptable to any ordinary typewriter. The mechanics of the plan for using it can be worked out to suit any individual need and it is also interesting to note that the cost is somewhat lower than that of the manifold form.

The third class of bills are those termed "final" where the service has been disconnected or there has been a change of occupancy of the property, bankruptcy, receivership, estates, etc. In handling the final bills where the customer has moved and left a forwarding address, the follow up is simple and presents no difficulties, and consists of the regular final bill, transfer of the bill to the consumer's new location; or if the consumer is not taking service at the new location, the follow up letters, calls by the Collection Department and finally

turning the account over to the regular attorneys or collection agency for their action.

In those cases where the consumer has made a cash deposit on his account, the final bill if not paid within a period of ten days should be deducted from the deposit and the customer notified by letter or telephone to call at the office and receive the balance due him from the deposit. Some utilities find it advisable to allow the consumer to provide a guarantor of his account in lieu of the cash deposit. This plan appears to work with more or less success, depending upon the company's attitude as to who may be accepted as a guarantor and the financial ability or willingness of the guarantor to pay bills which may be charged to him. There is an apparent tendency on the part of utility managers now to get away from the guarantor's agreement, because of the unfavorable results with regard to public relations.

In the matter of receiverships and bankruptcies, the procedure of collection is covered by law, and there is nothing that can be done except to see that the claim is properly filed with the court and await results.

In those plants municipally owned and operated where the utility bills are charged to the owner of the property, the question of collection of final bills is easily solved.

In this paper we have not attempted to describe in technical detail any of the mechanical equipment used in consumer accounting, but have attempted to show those methods employed in the up to date utility offices at the present time. If this paper results in giving any utility operator a new idea whereby he may more efficiently handle any line of customer accounting or give his customers a better service, we shall feel that we are amply repaid for our efforts.

(Presented at the Indiana Section meeting, April 12, 1934.)

RESPONSIBILITY FOR POTABILITY OF WATER DELIVERED

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By potability we mean those characteristics of a water supply which make it drinkable. Among the more commonly recognized indices of potability are:

(a) Taste and odor.

(b) Color.

(c) Turbidity.

(d) Absence of minerals such as iron that tend to affect the appearance of a water upon standing.

A potable water is one which is attractive to a thirsty individual.

PROGRESS IN IMPROVING POTABILITY

Marked improvement has been made in the quality of American water supplies in the last four decades, during which time, practically all turbid water supplies have been filtered and rapid strides made in improving the appearance, safety and more recently, the mineral content and potability of the supplies. The first cycle in this improvement was the removal of turbidity by filtration which markedly improved the physical appearance. Filtration in itself also largely reduced the health hazard of polluted water supplies and thus increased their potability. Filtration alone, however, did not afford complete protection against water borne disease. This was accomplished by the addition of chlorine first in the form of hypochlorite of lime and subsequently as liquid chlorine.

The use of liquid chlorine while protecting health, has, in combination with certain compounds and soluble substances in drinking water, in many cases resulted in chlorinous tastes and odors which have reduced the potability and been the source of complaint.

While potability and mineral content have long been considered in comparing the relative merits of available water supplies, it was formerly considered that both were more or less fixed qualities peculiar to individual supplies.

THE PUBLIC'S APPRAISAL OF POTABILITY

Until a few years ago, objectionable tastes in public water supplies were tolerated somewhat as a matter of course. If the municipal water supply occasionally had an unpleasant taste or odor, it was just too bad. That was something to be expected. The public would complain, but in general, patiently wait for the return of normal conditions, in the meantime, in many cases, reverting to the use of some nearby well for drinking water. That condition has changed very radically in the last few years. The knowledge of the prevention and removal of tastes and odors has been so greatly increased by the experiments of Baylis, Spaulding, Howard, Ellms, and many others as well by the operation of dozens of plants in the past few years that there is no reason why any water supply, except under the most unusual circumstances, should have a disagreeable taste. The public too has become "taste conscious." It knows that something can be done to prevent or relieve such conditions and promptly demands action.

A striking illustration of the public's appraisal of the potability of water supplies is afforded by the experience of the experimental filtration plant at Chicago. This plant has now been in operation about four years, its purpose being to determine the application and variation in standard methods of water filtration to particularly adapt them to the Chicago conditions. Chicago, with its pumpage of over 1,000 million gallons a day, is still drinking chlorinated, but unfiltered Lake Michigan water which at times resembles a chlorophenolic cocktail of rare potency.

This experimental plant has a capacity of one million gallons per day. It is equipped with standard appliances for feeding and mixing chemicals, coagulation and filtration, including experimental installations of all types of facilities for taste and odor removal. Chicago is faced with an expenditure of about $60,000,000 for water filtration. In order to acquaint the people of Chicago with the benefits of filtration, the filtered water has been available to all who would call at the plant. This has resulted in a growing appreciation of a potable water supply. At the present time, from 600 to 1000 automobiles a day visit this plant and carry away with them an average of from five to seven gallons of water. At infrequent periods due to the discharge of phenolic wastes into Lake Michigan from the Little Calumet River, the Chicago water supply carries a very disagreeable taste and odor. During such times, the number of daily visitors increases

to as high as 10,000 to 12,000 cars per day. The streets are crowded for blocks and the amount of water carried away is only limited by the ability of the people to reach the faucets. Mr. Baylis reports that many people come for this water from a distance as great as ten miles. This furnishes some measure of the Chicago public's appraisal of the value of a potable water as compared to the same water before treatment.

Another measure of the value of potable water is the amount purchased and the expenditure for bottled water in cities where the potability is poor. The aggregate expenditures for bottled water are enormous. As an average figure, probably $2.00 per million gallons is a high cost of taste and odor removal in a public water supply system. This cost of removing taste and odor from 1 million gallons is only equivalent to the cost of four 5 gallon bottles of commercial bottled drinking water, or expressed in another way, it is as cheap to correct taste and odor in 250,000 gallons of water in a properly equipped water works as it is to purchase one 5 gallon container of bottled water. If but one gallon of water in each 50,000 gallons pumped is used for drinking or cooking purposes in which potability is important, the economics of the comparison would point toward treatment of the entire supply.

Every water superintendent who has at any time had trouble with the potability of his water supply, knows that the telephone is one of the best indices of the public's appraisal. Some years ago, the speaker was in a water superintendent's office when the manager answered a telephone call. His end of the conversation was something like this: "Yes, it did taste bad.— It was due to algae. It will be all right now as we gave it a chemical treatment and the algae are dead and will cause no more trouble.—That was yesterday." The telephone receiver at the other end was hung with a bang. The manager then told me of the latter part of the other man's conversation, which was first, the question as "When did you kill those algae?" Upon being advised that the treatment was applied yesterday, the man at the other end who happened to be a physician, said "You're all wrong.—This has been dead for three weeks." A few months later, that water works property was in a condemnation proceeding and passed from private to public ownership.

Many instances might be cited where litigation with respect to rates and proceedings for the condemnation of private water works plants have directly resulted from unsatisfactory potability of the

public water supply. Within the past two weeks, in a public utility court hearing, the Attorney for the public admitted that the water rates were confiscatory and his only reason for opposing an increase was that the quality of the water had been unsatisfactory on two occasions both of which were over two years previous. Lack of potability frequently results in financial loss even though potability cannot well be expressed in dollars.

Privately owned water works are not alone in feeling the results of low potability. Many instances might be cited in which municipally owned plants have been severely criticized for dispensing safe, but not always potable water. So serious have these been in some instances that those in charge of plant operations have been displaced on that account.

POTABILITY AS A HEALTH MEASURE

People do not like bad tasting or bad smelling water. Either creates suspicion as to the purity of the supply. Frequently, when a public water supply is unpleasant to the taste, people leave that supply for one better tasting, but less safe bacterially. Poor potability may, therefore, lead directly to a health hazard.

A somewhat less direct measure of the effect of potability upon health may result from a decreased use of water for drinking purposes during periods when it is unsatisfactory in taste and odor. The human system requires a certain amount of water. The tendency is to reduce the use to below normal when the supply is not pleasant to the taste and smell.

This tendency is not peculiar alone to people. Livestock drinks sparingly if at all from a water containing excess chlorine or carrying certain tastes. In at least one instance, stockyards abandoned a water supply because of complaints from its patrons that the cattle would not drink fully of the water and accordingly, the "fill" was less than at other markets. With water selling inside the animal on a pound basis, potability assumes a direct money value.

LOW POTABILITY PREVENTION VS CORRECTION

One of the essentials to the maintenance of uniformly good potability in a public water supply lies in the operator's ability to anticipate the conditions leading to the lowering of the normal potability of that supply. If the tastes and odors occur due to algae, the operator should anticipate that situation by seasonal recurrences and analytical

control beginning prior to the time when such occurrences may be expected. He should analyze and ascertain whatever the conditions may be which cause low potability and anticipate their recurrence.

Taste and odor elimination is largely a question of prevention rather than of correction. It is believed that every plant which has at times received complaints due to tastes and odors, should have as daily routine, determinations of odor in the raw as well as the filtered water. In practically any filtration plant, it is practicable through such systematic observation of the raw water to prevent tastes and odors ever getting into the filtered water reservoirs or the mains.

Simple methods of taste and odor detection and calibration have been worked out by Spaulding, Baylis and others. The time required is not long. The technique is simple. These determinations should be routine observations wherever tastes and odors have appeared. Particular attention should be given to odor intensities and treatment required under varying conditions.

When tastes and odors do occur in systems which have them but intermittently, the operator's first responsibility is to maintain good potability. He should therefore not take time to determine the *least* treatment that will accomplish the result and run the risk of inferior water going to the consumers. His first duty is to see that potable water is furnished. He should give a treatment that will surely accomplish that purpose and that being assured, he can then ascertain how much that can be safely reduced. The public is much more concerned about one drink of bad tasting water than it is about whether it takes 200 or 40 pounds of powdered carbon per million gallons to make it tasteless—and incidentally the same operator and manager are more likely to be on the job next year when there is recurrence in the raw water than if they had attempted to solve the economics before they guaranteed a potable supply.

Another operating habit which will be of assistance in determining causes for tastes and odors, some of which develop in the distribution system, is the systematic investigation and recording of all complaints by localities, causes and time. Dead ends should be blown before rather than following complaints.

METHODS OF IMPROVING POTABILITY

The two most commonly used methods of improving the potability of the water supplies are through the use of activated carbon and the ammonia chlorine treatment.

Activated carbon can only be used in plants having filters on account of the necessity of removing the carbon after it has absorbed the tastes and odors and prior to the passage of the water to the distribution system. Over 400 plants are now using activated carbon for taste and odor removal in quantities ordinarily varying from 10 to 40 pounds per million gallons, although occasionally, instances are of record where as high as 200 pounds per million gallons has been required for a short period. The cost normally varies from $1.00 to $2.00 per million gallons, the equivalent of 0.1 to 0.2 of a cent per thousand gallons output.

Ammonia chlorine can be used in any system in which there is an appreciable time interval between the point of application and the point of take-off of the first consumer. Several hundred plants are now using ammonia chlorine treatment.

Some plants have no difficulty in furnishing a potable water at all times. Others are troubled intermittently and a few continuously. Although with careful analysis and observation, a potable water can be delivered from a plant having trouble only infrequently, it is believed that unless such intelligent continuous observations are made as will guarantee a potable water at all times, continuous treatment is justified.

CONCLUSION

That responsibility for furnishing a potable water supply exists cannot be questioned. The exercise of that responsibility in general lies directly with the water works management. With the facilities, knowledge and technique now available, it is practicable for nearly all plants to furnish a supply which is potable all of the time.

The water being furnished to the American public today is better than ever before and I believe is of the highest quality furnished anywhere. It can, however, still be improved, particularly along the lines of potability and reduced mineral content. The standards of quality and the requirements of the public with respect to water supplies today are more rigid than at any time in history. As each succeeding improvement in the quality is realized, the public forgets the past and demands something even more exacting. Supplies which would have been thought ideal a generation ago, are today considered unsatisfactory. Water works operators have the responsibility of delivering a potable water supply and to their credit, it should be stated that the responsibility is continually being more universally accepted.

(*Presented before the Indiana Section meeting, April 13, 1934.*)

VALUE OF AN ADEQUATE SUPPLY OF WATER FOR FIRE FIGHTING

By Malcolm Pirnie

(*Consulting Engineer, New York, N. Y.*)

During the deliberations on the economics of building in the early stages of the recovery program, a slogan was facetiously suggested that what the building industry needed was more and bigger fires. The reason for this thought grew out of consideration of the causes for the stagnation of the construction industry.

In the deflation period two families had moved into quarters formerly sheltering one in order to reduce the expense for dwellings. Other families and business organizations, through threats of moving to cheaper quarters, forced progressive reductions in rentals until the rentals collected at the beginning of the recovery program were not sufficient to meet the capital charges on the structures. This vicious spiral had finally removed all incentive for private capital to finance new building activities with the result that construction financed by private capital in 1933 was no more than 10 per cent of the volume in 1928.

Those normally employed in construction and the durable goods industries were progressively thrown out of employment, increasing the need for retrenchment in shelter expense, increasing the percentage of vacancies, forcing rentals to even lower levels and still further reducing the incentive for capital to create new structures. Aside from the slogan uttered in jest a suggestion was advanced having considerable merit which would provide a subsidy for the demolition of antiquated housing. This, it was pointed out, would reduce existing vacancies and hasten the day when a shortage in space for shelter and business would occur and cause a rise in rentals.

The policies of the recovery program itself increased the cost of building precipitately from the low levels in June, 1933, to costs approaching those of 1926. This is the obvious result of shorter hours requiring higher hourly rates of pay as the cost of construction from the raw materials in the ground through to the finished structure is represented by multiplying man hours by hourly rates of pay.

Thus in the trough of a depression demolition of antiquated structures would be necessary to hasten the return of an incentive for building, but no one seriously thought, even under these conditions, that destruction by fire could even be considered an aid to economic recovery.

FIRE LOSSES

Fire out of control is one of the greatest of the burdens in our national economy. Conflagrations often start in small fires in obsolete housing areas gaining headway there and sweeping through the high value districts destroying the community's supporting industries, stores and most modern housing.

The national fire losses in 1933 were a marked improvement over the conditions in the previous year, but were still the staggering total of \$400,000,000 against \$500,000,000 in 1932. These annual losses must be apportioned among the property owners of the nation and except for the proportion of loss suffered by uninsured property, this is done through the medium of insurance premiums. The insurance agencies of the nation must therefore know how to stipulate premiums on their risks to pay operating costs, annual losses and create reserves to care for 20 per cent fluctuations in annual losses and extraordinary losses which result from occasional disasters. The studies of these agencies for a long period of years have developed ratings which give due consideration to the fire protection provided and reflect to some degree the reduced risks in lower insurance rates. No reductions in rates on structures of inflammable material are possible without a water supply. For this reason, in the standard schedule for rating cities and towns of the United States with reference to their fire defenses and physical conditions, the National Board of Fire Underwriters has designated the largest number of possible points of deficiency to the water supply. Next in importance comes the fire department, followed by structural conditions, fire alarm system, hazards, building laws of the community, and police. The financial benefits from fire protection provisions can be realized by property owners only insofar as the insurance agencies recognize the value of the protection afforded. In these circumstances the requirements of the National Board of Fire Underwriters and the various state boards throughout the country are the best index of the relative value of fire protection afforded by the water works.

UNDERWRITERS' REQUIREMENTS

It is a simple matter to determine the Underwriters' requirements for dependability and capacity of the water works system. The requirements for capacity have a considerable influence on the cost of the distribution system as this must be capable of delivering the quantity of water required for fighting fires in addition to the average rate of water consumption on the maximum day of record. The proportion of the distribution system, therefore, devoted to fire service is the ratio between the fire requirements and the maximum day, plus fire requirements. This ratio of fire demand to maximum day plus fire demand may vary from 80 per cent in a community of 2,000 to 30 per cent in a community of 370,000, showing clearly that the costs of distribution systems in the smaller communities are largely dictated by the capacity necessary for adequate water available for fighting fires.

The proportions of supply works, filters, low and high service reservoirs and pumping stations chargeable to fire protection are influenced to varying degrees by their arrangements in the system and relative capacities.

It is recognized in some communities where the dry weather sprinkling load or extreme cold weather protection against freezing is a factor in consumer demand, maximum hourly rates of consumption may exceed the average rate on the maximum day plus the fire demand. In such cases a much smaller proportion of the main supply pipes, filters and pumping stations are chargeable to fire protection than is the case in the distribution system. In some places supply works may be charged 100 per cent to consumer demand as contrasted with fire hydrants which are obviously chargeable 100 per cent to fire demand.

The maximum hourly consumption is due to simultaneous drafts upon the system by a considerable portion of all of the consumers connected to all parts of the distribution network. The fire demand, on the other hand, requires the concentration of a large volume of water in addition to the average consumption on the maximum day at any one point in the network of pipes. For this reason the maximum hourly demand without fire does not supply a figure of value in determining the proportion of the distribution system devoted to fire protection.

INDIANAPOLIS WATER COMPANY ALLOCATIONS

The allocation of the property of the Indianapolis Water Company to fire protection service will furnish a concrete example of the factors considered in determining what influence the fire demand has upon each major part of the water works system. For Indianapolis the Underwriters' formula requires a fire flow capacity of 23 m.g.d. for a period of 10 hours in excess of the consumers' demand as an average for the maximum day. For this City it was found that the average daily consumption for a year was 30.5 m.g.d. The maximum daily consumption was 54 m.g.d. and the fire demand over and above the maximum day required a capacity of 77 m.g.d. This fire demand was exceeded for a period of approximately three hours on the maximum day when, due to the sprinkling load, the maximum hourly rate of consumption exceeded 114 m.g.d. All factors considered it was determined that the fire demand upon the distribution system may be best represented by the ratio of 23 m.g.d. to 77 m.g.d., which is equal to 30 percent. Fire hydrants are allocated 100 percent to fire protection. Low level reservoirs are allocated $51\frac{1}{2}$ percent to fire protection based upon the requirement that they must hold 10 hours' supply at the 23 m.g.d. rate or $9\frac{1}{2}$ m.g. to satisfy the Underwriters' requirements. The usable capacity of these reservoirs was found to be $18\frac{1}{2}$ m.g. so that the proportion chargeable to fire protection was determined as the ratio of $9\frac{1}{2}$ million to $18\frac{1}{2}$ million. The conditions at the pumping stations, however, were clearly dictated by the requirements to meet the maximum demands of the consumers attached to the distribution system. This requirement was somewhat modified by the existence of elevated storage which reduced the maximum demand upon the pumping stations to 108 m.g.d. In these circumstances the proportion of pumping station capacity chargeable to fire protection is the fire demand for 23 m.g.d. divided by 108 plus 23 m.g.d., or $17\frac{1}{2}$ percent. No charge to fire protection was made in the supply and purification works as these were clearly required to their full capacity to furnish the normal consumer demands, and, due to the adequate capacity of low level reservoirs, no increment in draft upon these works would result from the fire fighting load.

To check the actual experience of the water works system in meeting requirements of the Underwriters to bring the water supply capacity at all parts of the distribution system to the proper level for adequate fire protection a study was made of a 10-year construction program during which over a million feet of pipe were laid in the

Indianapolis distribution system to determine what proportion of this program was required for fire service. It was found that $17\frac{1}{2}$ percent of the footage was purely dictated by requirements for fire protection, but due to the fact that this footage in large measure represented relatively large diameter pipes the per cent of cost excluding fire hydrants was 37.4 percent and including fire hydrants 41.1 percent. From this check study it was clear that the basis determined upon for allocation of the distribution system to fire protection resulted in a minimum proportion that should be assigned to this service.

In view of the fact that no portion of the supply and purification works or of the meters and services is chargeable to fire protection and the relatively low percentage of pumping equipment required for fire service, the proportion of annual cost of operation including capital charges, which was found to be chargeable to fire protection in Indianapolis was but $18\frac{1}{2}$ per cent of the total annual cost.

SAVINGS IN INSURANCE COSTS

It may be estimated roughly that the investment in fire fighting capacity of a water works system varies from 20 percent of the water works cost in a city the size of Indianapolis to more than 80 percent of the cost in a community of 2,000 people. The writer has recently had access to a confidential study of savings in insurance premiums which might be made by carrying out the water works betterments projected under the public works program in 112 communities of various sizes. The projected works totalled in estimated cost approximately $8,113,000 and varied from reinforcements to existing systems to the installation of entirely new systems in many of the smaller communities. The savings in insurance rates to be effected were based upon removal of deficiencies by the improvement in fire fighting capacity of the water systems and did not assume improvements in the fire departments, building codes and character of existing construction. The study was limited to pumping equipment, storage capacity, elevated storage, dependability of supply works, adequacy of fire hydrants and removal of existing hazards to pumping stations. The annual saving in insurance premiums to the property owners in the 112 communities was found to be $231,000 and obviously could be raised materially if other conditions affecting insurance could be correspondingly improved. The 1930 population of the 112 communities, as deter-

mined from the United States census, was 488,000, and the average population was therefore 4,360 per community. With this as a very rough guide it is reasonable to assume that on the average 70 percent of the projected betterments would be chargeable to fire protection, or a total of $5,680,000. In these circumstances the annual savings in insurance premiums would amount to over 4 percent on that portion of the projected works chargeable to fire protection. It is reasonable to expect that other fire protection means would follow the provision of adequate fire fighting water service and that the additional savings made possible by the availability of an adequate water supply should be credited in part to the water works systems. In these circumstances there is obviously no added burden placed upon the property owners of these 112 cities by virtue of an expenditure of $5,680,000 to provide improved fire fighting capacity in the water works systems. The balance of the projected expenditure would obviously be reflected in improved quality of water, dependability of source of supply and service to the individual consumers.

What does the property owner really pay for fire protection? In answering this question he must recognize that he first receives a credit in the form of a reduction in insurance per thousand dollars of insured value. He may offset against this reduction in insurance whatever he pays his community in taxes for fire protection to cover the annual charge made by the water department and in support of the fire alarm system and the fire department. If the community makes no fire protection charge it will be impossible for him to pick this cost accurately out of his water bill but it will be there as a charge for water consumed which would increase the burden to the large water consumer for fire protection in proportion to the benefits he receives. In some communities such a calculation no doubt will result in a credit, and in any case, the net cost for the fire protection provided will be found to be negligible.

VALUE OF FIRE PROTECTION

What is the value of fire protection? To answer this question we need but to reflect upon the annual property loss in the United States, which was $500,000,000 in 1932 and $100,000,000 less in the year just passed. If we take an average of $450,000,000 per year as the annual fire loss it amounts to 5 per cent on nine billion dollars. This would pay for all of the construction done for every purpose in

the United States in a normal construction year. It amounts to $72 per capita for every person now living in the United States. This per capita figure is twice the pre-war per capita value of water works in those communities having municipal water service, and is therefore a sufficient amount to pay the cost of constructing such systems today.

It is not contended that fire losses can be eliminated so long as structures are built with inflammable materials but it does not require a flight of the imagination to visualize at least twice the present annual fire loss if the bulk of our communities were without their present water works systems. If only double the present annual fire loss would result from the lack of the existing water works systems it follows that these systems throughout the nation are worth, for fire protection alone, what it would cost to build them today including supply and purification works and distribution systems supplying the consumers and protecting their properties from destruction by fire. *The value of an adequate supply of water for fire fighting is substantially greater than the cost of creating it.*

(Presented before the Indiana Section meeting, April 13, 1934.)

FROST CONDITIONS IN CANADA IN 1933–34

SUDBURY

By R. H. Martindale

(Superintendent, Water and Light Department, Sudbury, Ontario, Can.)

At Sudbury, over a period extending from November 1, 1933, to March 15, 1934, the damage caused by the extremely cold winter was:

82 water services frozen, 40 on City streets and 42 on private property.

73 water meters frozen, 3 on City property and 70 on private property.

59 fire hydrants frozen, 42 in the month of February alone, and 8 being the maximum number in any one day.

4 breaks in mains and services occurred, consisting of one 4-inch main, one 1½-inch main, one hydrant nipple and one house service, all due to frost.

At some places we have a frost penetration of 7 feet.

The methods of thawing out, were:

(a) Electricity from a portable pipe thawing transformer for water services.

(b) Steam from a portable boiler and hot water for fire hydrants.

(c) No mains required to be thawed out.

The work was carried on entirely by regular employees of the Water and Light Department which are under one head. The electric thawing was done by some of the linemen and the other work by regular waterworks employees.

The minimum depth of cover on water mains is 6 feet, mains usually being laid in 7 feet trench, thus giving slightly over 6 feet of cover on smaller pipe sizes.

Snow is regularly ploughed on all roadways and sidewalks of the City and motor traffic is maintained on all streets, throughout the winter.

While the foregoing list of troubles may sound formidable, the additional expense to the Department was not excessive, for the following reasons:

(1) All private thawing jobs were paid for at a minimum charge of $6.00 each.

(2) All frozen water meter repairs (70) on private property were charged against each particular account.

(3) Due to daily inspection of fire hydrants each freeze-up was detected at its early stages, and responded quickly to treatment.

During this period there were 24 outbreaks of fire with total losses of $32,905.00, of which a $26,000.00 loss occurred at one fire only. In every case the fire department found the hydrants ready.

Time and space do not permit going into further details, but in closing these remarks I should say that where sufficient earth cover can not be had for various reasons, the mains in such places should be insulated with suitable durable insulating materials.

We have fourteen bridge crossings of cast iron mains ranging in size from 6- to 12-inch, not one of which has given a particle of trouble during the coldest spell of winter weather experienced for many years.

PETERBOROUGH

By Ross L. Dobbin

(Manager, Public Utilities Commission, Peterborough, Ontario, Can.)

The winter of 1933–34 will long be remembered by water works superintendents, not only for the severity, but also for the multiplicity of troubles that arose as a consequence. All over Canada there have been reports of frozen hydrants, water services and mains.

The mean monthly temperatures recorded at Peterborough are shown below, and for comparison those for 1919–20 and for 1932–33 are included.

	Degrees Fahrenheit		
Month	*1919–1920*	*1932–1933*	*1933–1934*
November	33.26	30.38	24.36
December	17.9	25.42	15.52
January	4.81	26.79	18.87
February	14.3	20.38	3.23
March	31.21	28.19	24.32

The winter of 1919–1920 will be remembered as a very severe one, but the winter just past has eclipsed all records since 1896. January, 1920, had 22 days in which the temperature was below zero, and February of this year had the same number. However, the mean

temperature for February, 1934 was lower than that for January, 1920, and as a result frost penetration was greater.

PENETRATION OF FROST

Judging by the number of frozen services and their location it was found that the frost penetrated to a depth of from 6 to 7 feet in gravel with large stones and under pavement. Where there was no pavement the penetration was about a foot less. In sand or clay the penetration was much less and it is estimated that 5 feet would be the maximum. One peculiarity of this winter has been the manner in which the frost has continued to remain in the soil. At the present writing, March 31, we are still getting reports of frozen hydrants and services.

In Peterborough, no unusual difficulty was experienced until about February, when the low temperatures prevailing forced the frost down below the mains. From February 8 to March 31, 459 water services were thawed, all by electricity. The maximum number of calls in one day was on March 5, when 61 calls were received. The previous three days had been mild, and the water was running on the roadways, and it is believed that the large number of calls on the fifth was a result of consumers thinking the danger was over and closing water taps which had been open during the cold spell.

From March 7, the number of calls tapered off rapidly until at the end of the month we were receiving only one in three days.

PIPE-THAWING EQUIPMENT

In preparation for thawing services a truck had been rigged up with transformers and cut-outs, but it was soon found necessary to fit out another truck in order to keep up with the calls, and both outfits were kept busy from 7.00 a.m. to 6.00 p.m. every day including Sundays. When thaws were scattered over the city, twenty thaws were a good day's work, but as the frost penetrated deeper, and the calls came more frequently, it was often possible to make two thaws with one hook-up. The maximum number of thaws in one day of 10 hours by one outfit was 28. A foreman, two linesmen, one ground man and a truck driver operated this outfit.

One outfit used two 10 kw. transformers connected 2,200–110–55 volts, and the other—two 25 kv.-a. transformers connected the same way. The larger part of the time taken for a thaw was in moving from one location to the next, and connecting to the primary wires.

The actual time the current was on was only two or three minutes in most cases.

Some services took longer to thaw, but we think this was due partly to there being a greater length of pipe filled with ice and consequently more heat required to start the water moving. We found also that lead service pipes took longer than iron, and that the presence of leadite joints in the mains increased the time of thawing.

We had two leaks as a result of electrical thawing. These were lead services where a leather washer was used in making up the flanged joint at the curb cock. We also had one water meter connection burnt off for a similar reason. Three mains, one 6- and two 4-inch were thawed, and it required a total of three hours in each case with the 50 kv.-a. outfit to get the water moving. In thawing one of these mains a 6-inch joint at the hydrant bend was perforated and a leak resulted. These three mains were dead-ends where the flow resulting from use in the houses connected to them was not sufficient to keep the water in the main from freezing.

In the 6-inch main where the leadite joint was perforated, a considerable amount of sulphuretted hydrogen was generated which vented through the water services into the basements of the houses. The residents objected strenuously to the odor, but it soon passed away.

Where these mains were thawed, we experienced considerable difficulty with dirty water, no doubt this being caused by the ice in the main scraping off the tubercules as it moved to the opening. Continued flushing has removed this trouble, but it was rather astonishing how long the dirty water persisted.

FIRE HYDRANTS

We did not experience any more than the usual trouble with the fire hydrants until February 1, when our inspectors began to report increasing numbers of them frozen at the base. Altogether about 40 out of 325 have been frozen in the leads at one time or another. We have had a much larger number with ice in the barrel when surface water was getting in through the day, or from a leaky joint on the hydrant or lead. These latter were treated with hot water and salt, and pumped out as required. Where the lead was frozen we had considerably more trouble. Our portable steam boiler, which had not been in operation since 1920, proved to be of no use on account of leaky tubes, and we resorted to the use of barrels of very hot

water on a truck. As we were able to obtain this hot water without any difficulty we continued to use it rather than repair the old boiler. We found it quite effective and by running a barrel of hot water into the hydrant and out of the drip at the bottom we were able to keep these hydrants from freezing for a day or two. We found that we had to keep it up with the majority of them every two days.

We do not think that treating these hydrants with hot water was any more expensive than using the old portable steam boiler, as the truck travelled much faster. In 1920, when we used the boiler exclusively, frozen hydrants had to be treated about as often with steam as we had this winter with hot water.

About the middle of March, we secured on approval a small steam thawer which used kerosene as fuel. As the weather had moderated considerably and surface water was getting into the ground, we did not have enough hydrants to make a thorough test under the exacting conditions as in February. There is no doubt that this type of outfit is very useful in cleaning ice from the barrel of a hydrant, or in thawing ice underneath the valve, but we do not think its effect is as lasting as a large quantity of very hot water soaked into the surrounding soil.

However, as was said before, we received the portable thawer too late to be of much use, and cannot, therefore, make definite statements as to its usefulness.

We had two hydrants lifted by the frozen ground out of their bends. These were in clay soil, and in one case the frost jacket had slipped upward until it bound on the upper part of the hydrant, and then lifted the whole assembly. In the other case the hydrant had no frost jacket, and the uplift caused by the frost strained the flange bolts at the bottom, causing a leak.

After our experience in 1920, we re-set many hydrants that had given trouble, by purchasing longer hydrants to replace them, and lowering the leads from the main. Bends were used in many cases to get deep enough. We also installed vertical pipes of large diameter under the base of the hydrant which had the effect of bringing up the warmth from 8 to 10 feet further down. None of these hydrants gave us any trouble this winter.

Towards the end of the winter we had considerable trouble because of surface water getting into the hydrants and freezing in the barrel. This was after the frost had receded from the leads, but was still in

contact with the barrel. These hydrants were treated with salt and hot water and pumped out daily. We were also able to blow out the ice from the barrel by opening the hydrant and using a nozzle. This could only be done in soft weather when the water on the street surface did not freeze and cause a dangerous condition. The lubricant used in the stem packing of some hydrants congealed in the cold weather and it took considerable effort to open them. This was corrected by using zero grade motor oil.

FROZEN VALVES

We had unexpected trouble when operating some valves set in chambers, when the bonnets filled with ice. These valves could not be turned until they were thawed out with hot water and steam.

CORRECTIVE MEASURES

Looking back on the past winter's difficulties, and bearing in mind the experiences of former hard winters, it is evident that unceasing vigilance is necessary for successful operation of a water works system in severe winters. When a water service to a dwelling is frozen, aside from the inconvenience to the occupant, there is no great danger. But a frozen hydrant at the time of a fire is a black mark against a water works department.

There is only one way to prevent water services from freezing, and that is to lay them with sufficient cover. We thought at one time that 5 feet 6 inches of cover was enough, but this winter has proved that we should have more. If at all possible we intend to dig up all services that gave us trouble and relay them with at least 6 feet 6 inches of cover, and in some cases, 7 feet. We have also learned that catch basins for surface drains in proximity to service pipes conduct the cold to great depths, and consequently we will move either the catch basin or the service to get sufficient separation.

Such mains as were frozen in Peterborough were dead ends, and we will prevent freezing in future winters by connecting these into the grid, and thus getting circulation. This will cost considerable money, but there appears to be no alternative. We have had no mains frozen where there was sufficient circulation. Hydrants that were frozen will be gone over and in the majority of cases we will relay the lead with more cover, and at the same time install a shut-off valve. We will also add an extension on the barrel so that the hydrant valve will be lower down. Vertical pipes under the hydrants

will be installed. We shall also endeavor to locate the source of the water seeping into the barrel through the drain hole. This may be ground water, but in a winter like the past one, there cannot be much of this. We suspect that there are many small leaks on the leads, or in the boots, which ordinarily cause no bother, but with frost 6 feet in the ground, and in many cases below the hydrant valve, any water at all in the hydrant is sure to freeze.

After a water service is thawed electrically, water must be allowed to run continuously until the frost has left the soil around the pipe. This results in considerable wastage of water and must cost considerably in some cities. We estimate that in March there were about 600 services running continuously in Peterborough using an extra 900,000 gallons of water per day. The pumpage figures for this winter and last are given below for comparison.

	Gallons per day	
Month	*1933–1934*	*1932–1933*
November	2,350,800	2,230,000
December	2,416,400	2,248,000
January	2,590,000	2,203,742
February	3,129,000	2,255,200
March	3,310,000	2,225,500

COST OF THAWING SERVICES

Fortunately in Peterborough we did not have to use any alum at the filtration plant this winter because the raw water had a very low color, and the extra cost on account of the increased pumpage would not be more than $300.

The extra labor cost of taking care of the hydrants would be about $300, not including regular inspection, as this is done every year. We used eighteen bags of salt costing about $25. The labor cost to thaw 459 services by electricity amounted to $1,097.79, making the average cost per service $2.39. This cost did not include any charge for equipment as the electrical apparatus employed will all be used in the regular way for construction purposes. No cost of power used is included as this was entirely off-peak. The extra cost to the water works department on account of the severe winter season will total $1,700.

OTTAWA

By W. E. Macdonald

(City Water Works Engineer, Ottawa, Ontario, Can.)

In Ottawa, the winter of 1933–1934 will long be remembered, particularly by the members of the City Water Department. This winter has been the coldest in the history of the city in the last 43 years and the temperature at one time dropped to 45 degrees below zero. During the month of February there was only one day when the temperature did not go below zero at some time during the 24 hour period.

EXTENT OF TROUBLE

Extension of new water mains

During the extremely cold weather where trenches expose water mains and services it has been found positively necessary to insulate all the mains and services by wrapping with hair felt and encasing in mineral wool.

Sectional shut-downs

In proceeding with extensions to the system or when effecting repairs to the system in cold weather it has been found necessary, during the past year, to have all water services blown out, back to the main by the use of compressed air. This action had to be taken immediately after closing down the section and greatly tended to reduce the freezing of services in the immediate locality.

Construction works and repairs

In many instances it was found advisable to test all mains and services prior to backfilling under pressure of compressed air, and prior to backfilling, mains were first covered with a minimum of one foot of shavings, while all exposed services were wrapped with several layers of hair-felt.

Sprinkler systems

During the past winter many 6-inch cast iron mains under the city streets which supplied private sprinkler systems became frozen. For many years past I have strongly advocated the policy of tapping these 6-inch mains immediately inside of the property wall and connecting the domestic or commercial service under meter at this point.

This proposed method would create a velocity in the 6-inch main during the 24-hour period and greatly tend to minimize the possibility of the sprinkler service becoming frozen. For the information of this Meeting I might state that I have again taken this matter up with the Sprinkler Risk Division of the Canadian Fire Underwriters' Association and this recommendation is, at the present time, under consideration by their Board.

Gate valves

This year the cold weather was sustained over the entire month of February and as evidenced by the fact that during the month there were only four days on which the thermometer did not at some time in each twenty-four hours reach a temperature of below zero and on several days continued from 30 to 42 degrees below zero. This continued cold spell was responsible for sending the frost down to a depth of 7 feet 6 inches on practically all of the commercial streets of the City of Ottawa, with the result that practically all gate valves in the entire distribution system had to receive an application of steam before same could be operated. This factor alone was directly responsible for the additional time required effecting shut-downs of all areas.

Heating mains by electricity

The writer has considered in extreme cases to protect mains from freezing, the installation of a spirally wound copper wire on the outside of the cast iron mains proper which would be connected at various intervals to the permanent source of electric energy of one of the power Companies. From experiments conducted to date, it appears that the following procedure could safely be followed:

Continuous power supply

If the power were continuously applied during the extreme cold weather it appears that an application of 1½ watt per 6-inch pipe and of 2 watts for 8-inch pipe in the City of Ottawa where the pipe would be installed with a minimum covering of seven feet. In the use of the above method it has been estimated that it has been necessary to tap the main every 500 feet, using 22 volts, and this plan could be carried out on a 6-inch water main, using 1,000 feet on No. 8 weather proof copper wire, wound helically around the 6-inch main. This proposed installation would require 50 pounds of copper wire costing

$13.50, or the equivalent of 2.7 cents per foot of pipe for the wire only. The above method is recommended in extreme cases only.

Increase in maintenance operations

The work of the Maintenance Division of the Water Department in the month of February, 1934, represented an increase of over 700 percent as compared to February of the previous year. In February, 1933, the Water Department was called upon to perform 593 service operations during the month, whereas in the month of February this year the Department was called upon to render service to 4118 demands made in the Maintenance Division alone. This abnormal increase required the additional expenditure of $4,600.00 over and above the similar period of the previous year.

This unexpected cold spell naturally resulted in a greatly increased number of calls being received by the Water Department, the majority of which were from frozen services and up to March 28, this year, the total services thawed out for the winter were 1672. In addition to these services there were 27 water mains frozen in the city and during the extremely cold weather and throughout the entire month of February, it was found necessary to send the steam boiler to steam out between 75 and 100 hydrants daily. Practically all of these hydrants were dry frozen and it has been necessary to lift and repair more than fifty which have been damaged by the frost during the last three months. The total length of water mains frozen in the city exceeded 3000 lineal feet.

As a result of these frozen services and mains, numerous leaks developed most of which were immediately found and repaired, but it will be necessary to make an intensive pitometer survey this summer before this waste water can be controlled.

In our City we now consider that it will be worth while having a clause inserted in the Building By-laws making it compulsory in the future to leave a sleeve of some insulating material in foundation walls through which the water service could pass. Our experience has been that in a great many cases the service freezes just at the foundation, and this is no doubt due to the fact that frost is carried down to the service by the foundation wall itself.

Six water mains, 6 and 8 inches in diameter were split for a distance of 320 lineal feet and had to be relaid. Another 8-inch main on Parliament Hill was frozen solidly for 250 feet and since thawing out, three leaks have developed and been repaired and this whole stretch will have to be replaced.

The intense cold also necessitated the insulation of all check valves separating the Booster System used for higher fire pressure in the business districts, from the other mains in the city. These valves and pipe were all wrapped with hair felt, covered with 3-inch tape.

This same insulating process was used in connection with the air valves on the high pressure line and in most cases electric heaters were installed in these chambers as an added precaution.

It was also necessary to open up all blow-offs on dead ends throughout the city, which has considerably increased the consumption but has been a great aid in keeping these mains from freezing.

In connection with the two main feeder pipes to the city, 51 inches in diameter, it was necessary to install a special heating system where the pipes crossed under the bridge from our main pumping station to the mainland. These pipes had been insulated to withstand a temperature of 30° below zero, but as the temperature was more than 40° below for a period of three consecutive days, added precaution was taken, by having steam boilers and salamanders placed in the pipe space, and the temperature of the circumambient atmosphere kept at, above or close to the freezing point.

Settling basins

The excessively cold weather of the past winter caused ice to form over the settling basins to such a thickness as to cause some concern. In the early part of the winter the ice was broken up through the manholes by means of ice chisels. This did not prove satisfactory, as one cake of ice would float over another, the two would freeze together, and the last condition would be worse than the first. During the latter part of the winter the settling basins were emptied at frequent intervals, the ice cakes were broken up, and the ice flushed out through the drain sluice. The greatest thickness of ice on the settling basins at any time was 7 inches.

Water level controller

Some trouble was experienced with the pipe line connecting the Increaseometer Arm in the filter building with the pendulum unit in the pumping station, which runs along an exterior wall. This was overcome by encasing the pipe, and placing an electrical strip heater inside of the encasement.

The auxiliary hydraulic pumping station

Anchor ice troubles at this station were reduced to a minimum by keeping the head water at as high an elevation as possible, and on some occasions by wasting untreated water over the spillway. The ice in the forebay was broken up at frequent intervals by blasting.

The pumps at the hydraulic station were given a higher proportion of the total load to carry than is customary, in order to increase the velocity through the pipe line supplying this station and all pumps were operated at various intervals during each twenty-four hours to prevent the freezing of the water wheels.

DEPTH OF FROST

Ordinarily the frost rarely penetrated more than 5 feet below the surface of the ground, but this year in ordinary earth, it was found that the frost had penetrated at least 8 feet. As a matter of fact one of our 6-inch mains, covered with 7 feet 3 inches of earth and asphalt topping, was found to be frozen solidly for a distance of more than 60 lineal feet. This condition was found only where the snow had been removed from the streets.

When relaying a new water main on one of our city streets the frost was over 6 feet deep on the street where the snow had been ploughed off, but when it was necessary to install a service from this main it was found that near the street line where the ground was covered with four feet of snow, the frost had only penetrated 18 inches.

METHODS USED FOR THAWING

a. Electrical thawing apparatus

The present method of thawing services by the self-contained electric thawing apparatus designed and patented by W. E. MacDonald, City Water Works Engineer, Ottawa, Canada, has reduced the cost from the former transformer method and has resulted in a reduction of \$4.27 per service, or during the past fifteen years has effected a total saving to the city of \$31,427.20. This year alone the City has been able to make a saving of \$7,139.44 by using these machines. During the past winter we have built two new machines making a total of five in the Department.

These machines have given excellent service and are used for thawing all kinds of water services, mains or hydrants. The time required for thawing services varies from 1½ minutes to probably ½ an hour or

longer, according to the difficulties encountered, but during this past winter one of the machines was sent to Westboro to thaw out ten services and exactly one hour had elapsed from the time the machine left the garage travelling three miles to Westboro and completing the thawing of these services.

During the last week another of these machines was used to thaw out a 6-inch fire service which was known to have been frozen for more than a month and this main was thawed out in slightly less than one hour.

All these machines are mounted on trucks.

b. Steam boilers

The City of Ottawa Water Department also has a fleet of six steam boilers mounted on trucks.

These boilers were generally used to thaw out hydrants most of which were caught at the valve. However, when the electric machines were too busy to spend a great length of time on the mains, the boilers were brought into use in employing the use of steam. The main was first uncovered and a section of the pipe cut out. Then steam was conveyed by copper tubing inside the pipe for thawing purposes. This system, although very effective, is much slower than by using the electric apparatus.

In one or two instances only have we had to use steam on some services where we could not get a proper electrical connection, for varying reasons, such as on a private service in the Village of Rockcliffe. This was found to have been previously repaired. A damaged 1-inch galvanized pipe was cut and joined up with a piece of hose. Naturally the electric current would not pass through.

ADMINISTRATION OF THIS WORK

The City of Ottawa, Water Department, carried a 24 hour service with an engineer in charge of the maintenance division and another engineer in constant control of the pumping stations.

All service calls were received at our distribution office and all operations were controlled from there.

It has been the policy of the Department to charge $3.00 for each half hour a thawing machine is required on any service where such service is frozen on private property. By a special arrangement, the property owners are allowed to pay this money to the operator direct who must receive the money before starting to thaw the service. All

operators are provided with receipt books and must give a receipt for every service rendered. The money is then turned over by the operator to the clerk on duty who will then check the receipt book and will turn the total amount in to the City Treasurer's Department daily.

A follow-up system on all these operations is continuously carried on by one of the Assistant Engineers or other competent employees who keep in touch with all machines and see that all difficulties are remedied as speedily as possible.

DEPTH OF MAINS

It has been a standard practice in the City to see that all water mains and services have a minimum of 6 feet covering over them.

SNOW REMOVAL FROM PAVEMENT

The snow is ploughed to the pavements on all business streets and it has been my experience this winter that this has been the cause of most of our frozen mains and services. As a matter of fact, I notified our Board of Control last fall that this practice if allowed to be followed out would result in a serious situation to our water mains.

ADDITIONAL FEATURES

There is one feature that has not been mentioned in this report and that is the daily inspection of fire hydrants.

It has been the custom for some years to have experienced hydrant inspectors make a daily inspection of the fire hydrants and report immediately to the Central Office any hydrant out of order, so that same may be placed in commission without further delay.

Steam boilers are always in readiness during the twenty-four hour period and respond to all fire calls. Immediately on arrival at the scene of the fire the boiler man checks up on all hydrants likely to be used and then tests all hydrants in the outlying area if the fire looks in the least serious. He then keeps in constant touch with the firemen to give any assistance possible in thawing hose connections, etc. In connection with this phase of our work I might state that, although the number of fires during the past winter was greatly in excess of previous years, there was only one hydrant found by the firemen to be out of order. As the steam boiler was actually on the scene the firemen were enabled to use this hydrant after a delay of only five minutes.

Another precaution taken when it was found the mains were freezing, was to send out parties of men after midnight to blow off hydrants in the business area allowing a stream to run full from each hydrant for 15 minutes. In this way it was possible to break up the ice forming in the mains.

RELIEF WORKS

During this winter the City of Ottawa carried on an extensive relief program and as a result numerous mains and services were exposed by the sewer department when excavating for these sewers.

This work caused a greatly increased amount of labor to the Water Department due to the services and mains freezing and necessitating the constant inspection of the various works to see that all such mains and services are sufficiently supported to prevent them from breaking when backfilling is done.

FUTURE POLICY OF DEPARTMENT

As this year's extremely cold weather has shown that the frost has penetrated considerably lower than in the past, the Water Department has inaugurated a policy of laying all mains with a minimum covering of 7 feet.

All frozen mains and services have been listed and it is proposed to see that all these mains and services are lowered. This policy is to be particularly followed out in the business districts where the snow is removed from the streets.

All property owners whose services have been frozen on private property or who have been forced to let their taps run to prevent the services from freezing are being notified that these service pipes must all be insulated to prevent future waste of water.

(*Presented before the Canadian Section meeting, April 6, 1934.*)

OPERATIONS IN THE JACKSONVILLE METER DEPARTMENT

By J. E. Herring

(*In Charge Meter Department, Jacksonville, Fla.*)

Some call the water meter a retarding mechanism, but the water department cash register is also a good definition for it, for by it all the water bills are made out and if your meter is not in good working condition, your cash register is not taking in the cash it should. There are a few more important duties which the water department is called upon to perform than estimating what is the proper and just amount of water to be charged for when the meter has stopped registering.

The department head in these days of abnormal costs wishes to see that his department receives what it is honestly entitled to, and in this he is not asking the consumer to pay for service he did not receive. If the meter is not registering can he with the information available, make a bill which he believes will be satisfactory to the consumer? Or supposing that he makes a bill which he believes to be just, but which the consumer may dispute, how will your commissioners or department heads view the matter? They may not share with the meter man the confidence in the water meter which his experience has given him, but rather incline to the more or less general distrust of the meter on the part of the public.

Occasionally there will be the case of a consumer who merely objects to paying the bill. He may be sincere in feeling that the bill is too high or he may know better and just want to stand the bill off that much longer. In that case we have to send out and get the meter, bring it into the shop and make a special test of that particular meter. Ninety-eight percent of the meters brought in for special test (that is, a disputed bill) will register O.K.

It is well to keep in mind that, as a general rule, if any question arises about the test of the meter or in making an estimated bill, the benefit of the doubt is given to the consumer.

The meters are read every month, and the bills are sent out quarterly, except the large accounts which are sent out monthly. This

makes it easy if you have to estimate a bill. If anything should go wrong with the meter the meter reader will catch it before it has gone too long. A meter which is not registering should be discovered at the earliest opportunity.

The meter readers report all meters that are not registering, a ticket is made out at the city hall for that meter to be changed, and the ticket is sent to the meter shop. There a crew takes charge of the ticket and installs another meter in place of the one that is not registering. This meter when brought into the shop is cleaned out and checked over thoroughly, and all the worn parts are replaced with new ones, and then it is placed on the test bench where three tests are made as follows: (a) $\frac{1}{8}$ inch with five cubic feet; (b) $\frac{1}{4}$ inch with ten cubic feet; and (c) open flow with ten cubic feet. This test applies to the $\frac{5}{8}$- and $\frac{3}{4}$-inch meter. (This is a non-chargeable account.)

The $\frac{5}{8}$- and $\frac{3}{4}$-inch meters are tested in series of ten. The 1-inch meters up to and including the 2-inch are tested singly. We have two Mueller Test Benches, one in series of ten, and one singly. We have one forty cubic foot tank set on scales that takes care of both test benches. The outlet pipe from the test bench is equipped with a quick operating valve, and the pipe to the tank is so arranged that it will stay full of water at all times.

Every meter before it leaves the shop for service must register at least 97 and not over $99\frac{1}{2}$ percent; this, as I said before, is to give the consumer the benefit of the doubt.

Sometimes a meter comes into the shop that has not been out more than three or four days. This is not always the fault of the meter, but sand and other matters in the main may account for the defect.

We change meters only when they are not registering or on account of a disputed bill. Broken dials and glasses are repaired on the premises. Periodic testing of meters, especially the small meters, is unnecessary and uneconomical. An investigation of this question in 1930 disclosed that it was not advisable from an economical standpoint.

One man in the shop repairs and tests all meters. Two men work out from the shop that change all meters that are not registering, also all meters on account of disputed bills, and all other necessary repairs that can be done without bringing the meter to the shop. About every thirty days the city hall furnishes a list of meters at vacant houses that have been vacant for some time. The meter

crew takes the list and brings in all these meters and they are all checked over and tested. All meters that will not come up to the required test and will cost too much to repair are junked.

We have about thirty thousand meters in Jacksonville, and it is a very easy matter for one man to take care of the repairs on them. About all of our meters now have the inclosed oil gear train. Those that have not, as fast as they come into the shop, are immediately changed over, so we have very little trouble with the train gear. But we do have some trouble with the measuring chamber and disc. Some of them we can repair and some of them we send back to the factory to be reconditioned and fitted with new disc. We have them fitted with new disc because they can make a better fit at the factory than we can at the shop. The job complete is very reasonable and at the same time the chambers are electro-tinned. The chamber then is almost as good as a new one.

We sometimes get a meter where the disc is warped. This, of course, is caused from hot water backing up to the meter, and there are only two remedies for this. One is to have the consumer install a check valve on his line, and the other is to replace the cold water disc with a hot water disc. We have some wear on the disc ball, also in the ball seat of the chamber. This can be taken up quite a bit if you have a three piece disc, by taking off the half ball and inserting a thin piece of paper between the disc and ball.

We have very little trouble with the register. Only at times when a consumer has quite a large excess bill, the register will have the appearance of having been smashed with a hammer. In this case the consumer is sent a bill to cover the cost of a new register.

The meters in Jacksonville are in better condition now than they have ever been. The cost per meter per year is about four cents. This does not include labor.

We have one crew of two men that takes care of the large meters of which there are one hundred and one, in sizes from 3 to 8 inches inclusive. These meters are cleaned out and tested twice a year without moving the meter from the premises, and without interference with the consumers water supply. We have a by-pass on all of the meters.

We have a 3-inch test meter of the velocity type for the large flow and a $\frac{5}{8}$-inch meter for the small flow. These two meters are connected to the meter to be tested with a $2\frac{1}{2}$-inch high-pressure hose, the flow through the 3-inch meter being controlled by a 3-inch quick

closing valve, and the flows through the small meter being controlled by a $\frac{3}{4}$-inch valve on the side of the 3-inch meter. This test meter is tested regularly to be sure that it is O.K. The large meters are tested on four flows as follows: 2- and 1-inch with one hundred cubic feet, and the $\frac{3}{4}$- and $\frac{1}{2}$-inch with ten cubic feet.

Each month I receive a copy of the water bills on all large meters. This is done so that I may keep a check on how they are registering and if there is a great deal of difference in the bills I immediately make an investigation of that service.

From my experience with the water meter I should advise all water departments to keep a close check on all meters, especially the large meters, for they are your cash registers.

(Presented before the Florida Section meeting, April 17, 1934.)

DISTRIBUTION SYSTEM DESIGN AND UPKEEP

By Robert A. Duff

(*Engineer and Superintendent, Medford Water Commission, Medford, Ore.*)

Every city should have a definite plan for its distribution system. No doubt the ideal situation would be a twenty or twenty-five year plan, revised every five years or projected into five year divisions. This plan would preferably be based on a pitometer survey in which the present capacities and normal consumption of existing mains are determined. From here a study should be made of population trends, probable growth estimated from the projection of the population curve and allocation of this growth is then made into districts. The districts, in turn, are classified into their probable utilization, whether for residential, industrial, or business purposes. Local planning commissions might very well be consulted here, for these commissions, in a measure, will shape the growth of future communities.

DESIGN

A distribution system must be designed to maintain adequate service pressure under the maximum condition of draft which may reasonably be demanded of it.

A normal static pressure of 60 to 75 pounds per square inch is now considered desirable for the following reasons:

1. It will supply ordinary consumption for buildings up to ten stories in height.
2. Gives effective sprinkler service in buildings of four or five stories.
3. Permits direct hydrant service for a few hose streams insuring quicker operation by the fire department.
4. Allows a larger margin of fluctuation in local pressures.
5. Brings in revenue from hydraulic appliances.
6. Is of greater service to residents for lawn sprinkling.

The maximum demand for which a system must be designed is the coincident draft of ordinary consumption, plus the estimated fire demand.

It is common practice to consider the ordinary consumption, to be used in design, as the ordinary draft at the average rate of the maximum day. Some engineers contend that the absolute maximum rate of domestic consumption be used, while others suggest that the average daily demand of the maximum one week will suffice.

The average per capita per day consumption will vary, depending upon the locality and local conditions, ranging from 40 in a tightly metered city to 300 gallons per day in some of our unmetered western towns and cities.

The generally accepted practice for estimating the quantity of water which should be available for fire service is the formula used by the National Board of Fire Underwriters,

$$G = 1020\sqrt{P}\,(1 - 0.01\sqrt{P})$$

TABLE 1

Required fire flow

POPULATION	REQUIRED FIRE FLOW, GALLONS PER MINUTE FOR AVERAGE CITY	POPULATION	REQUIRED FIRE FLOW, GALLONS PER MINUTE FOR AVERAGE CITY
1,000	1,000	28,000	5,000
2,000	1,500	40,000	6,000
4,000	2,000	60,000	7,000
6,000	2,500	80,000	8,000
10,000	3,000	100,000	9,000
13,000	3,500	125,000	10,000
17,000	4,000	150,000	11,000
22,000	4,500	200,000	12,000

where G = required flow in gallons per minute, including an allowance for probable loss from a broken connection incident to a large fire, and P = the population in thousands.

Over 200,000 population, 12,000 gallons a minute, with 2,000 to 8,000 gallons additional for a second fire.

The Underwriters recommend five hours fire flow for towns of less than 2,500 population and ten hours for larger communities.

ARTERIAL AND GRID LAYOUT

It is better to have several arterial or feeder lines coming from the supply and entering the distribution system than it is to depend on just one large one. A failure on the one line supply might cut off a

large part of the system, while a failure on one of the smaller lines would isolate a correspondingly less part of the system.

Primary or trunk main feeders should be spaced approximately 3000 feet apart and gated every quarter of a mile.

The secondary feeders which form the network of pipes of intermediate sizes and reinforce the distribution grid within the boundaries of the primary feeder system and in the concentration of the required fire flow at any point, are also systematically spaced. All primary and secondary feeders should be looped and cross-connected.

The minor distributors or gridiron system should consist of 6-inch and larger pipe. Four-inch should never be used in the system where a fire supply must be drawn. A 6-inch main in the gridiron should be cross-connected at intervals not greater than 600 feet. In high value districts 8-inch should be substituted for 6-inch in the grid system and they should be cross-connected at the same interval as the 6-inch.

STORAGE

Distribution storage reservoirs have many advantages and should be given a prominent place in the design of the system. These reservoirs provide a more uniform pressure, flatten out the demands of peak loads on the system, permit the installation of smaller pumps, allow pumping when there is less demand for power thereby insuring a cheaper rate, and provide an emergency storage which will take care of service while repairs are being made.

The ideal location for a distribution reservoir would be on the opposite side of the city from which the supply enters, this condition would provide a feed from both directions in time of maximum draft, and would bring the supply line through the center of the distribution system thereby reinforcing the feeder lines. This condition is not always available and depends more or less on the topographical layout of the country.

The National Fire Underwriters recommend a five day storage capacity draft or ordinary consumption with a 10 hour fire demand in addition.

FIRE HYDRANTS

Fire hydrants should have the following characteristics:

1. Be of simple and rugged construction.
2. Operate freely.
3. Drain when closed and not leak when open.

4. Discharge with minimum loss of pressure.
5. Permit withdrawal of working parts from top of barrel.
6. Be dry when barrel is broken by collision.

Hydrants should be able to deliver 600 gallons a minute with a loss of not more than 2½ pounds in the hydrant, have at least a 6-inch main connection, and should have at least two 2½-inch hose connections and also one steamer connection. Hose threads on outlets should conform to the national standard and all hydrants should be gated between the main and hydrant.

TABLE 2

Average area to be served by hydrant

FIRE FLOW REQUIRED GALLONS PER MINUTE	AVERAGE AREA PER HYDRANT	
	Engine streams	Direct hydrant streams
1,000	120,000	100,000
2,000	110,000	85,000
3,000	100,000	70,000
4,000	90,000	55,000
5,000	85,000	40,000
6,000	80,000	40,000
7,000	70,000	40,000
8,000	60,000	40,000
9,000	55,000	40,000
10,000	48,000	40,000
11,000	43,000	40,000
12,000	40,000	40,000

In the "Standard Schedule for Grading Cities and Towns of the United States—1930" the National Board of Fire Underwriters recommends spacing according to table 2.

Where direct streams are used 4- or 6-way hydrants with independent gates or outlets may be assumed as two hydrants in figuring area served, where two engines are connected to a hydrant with two steamer connections this may be considered as 1½ hydrants.

As a general proposition, a hydrant should be located at each street intersection with intermediate hydrants as the spacing demands.

GATE VALVES

Gate valves should be plentiful and strategically situated. Seldom do we hear that a system has too many gates, while the reverse of this statement is often repeated.

All branches from feeder mains should be gated, intersections should have at least two and preferably four valves. Cross-connections between feeder mains should have a gate at both ends, all valves should be systematically located with reference to street lines, accurate record and history of each valve should be kept. All valves in a system should operate in the same direction.

RECORDS

After construction a distribution system is back-filled, buried and probably never exposed again during the life of the administration that guided its construction. During the life of the structure the only evidence of it are the records that show its physical construction. No doubt these records are of nearly as great value as the structure itself.

Duplicate records should be kept and should be indexed in convenient form, kept up-to-date and safely filed.

UPKEEP

A distribution system is one class of structure that will glaringly manifest any neglect on the part of its maintenance and for this reason most systems are diligently cared for, as far as any material deterioration is concerned. But there are phases that can be classified under upkeep that are sometimes neglected. They are noted here briefly.

Continuously recorded pressure gauge records should be kept from widely located points on the system. These records are invaluable in studying pressure drops and are vital indices of the condition of the system at all times.

In a city with a highly corrosive water it is advisable and economical at times to have mains cleaned. This practice is becoming increasingly more common. Often, as a result of these cleanings, such an increase in capacity is experienced that the extension of new or larger mains is forestalled.

All valves should be regularly inspected once a year and a history of this inspection should be kept and filed in convenient form.

All fire hydrants should be inspected in the spring and fall and after severe cold weather. For the sake of appearance and protection they should be repainted at regular intervals.

An emergency crew with completely equipped truck should be available within a few minutes notice. One well equipped truck

should respond to all fire alarms in business or industrial districts and to second alarms in other districts.

Repair parts should be stocked for valves, hydrants, etc. Extra lengths of various sized pipes should also be stocked, for all these materials even though of high quality are subject to breakage.

(*Presented before the Pacific Northwest Section meeting, May 12, 1934.*)

EFFECT OF METERIZATION ON REVENUES AND CONSUMPTION

By E. H. Ruehl

(*Town Manager, Bluefield, Va.*)

When a drought period, several of which we have had in the last ten years, prevails in a community in which the water services are not metered, there is usually a shortage of water or at least a reduction in pressure. Considerable complaint is registered by the people living on the higher elevations when there is insufficient pressure to supply their domestic needs, while the people on the lower elevations are sprinkling lawns, washing cars, etc. Such a complaint is justified as the people living on the higher elevations pay just as much for water service under a flat rate system as those living on the lower levels. Such is a typical case of unbalanced consumption and charges. Metering will correct it and sometimes under conditions like this people will urge metering.

As soon as metering is discussed in a community, however, considerable opposition generally arises thereto, with reasons put forth that it will force people to use less water than is necessary in order to keep the water charges from becoming high and burdensome. In reality it is the first step to keep water rates at a minimum. Thanks to the fortitude of water works and thinking municipal officials the installation of water meters is on the increase. In spite of considerable opposition in many cases before meters are installed, the writer knows of no case where meters, once installed, have been discarded for political or other reasons.

This experience alone should indicate, in a broad sense, that the installation of meters is economically sound.

It does not necessarily follow that as soon as meters are installed in the service lines of a water system total revenues will be on the increase, but it is invariably true that wastage is cut down and net revenue will increase, affecting parts of the plant remote from the meters.

There are some cases where it might not be apparent at once that

metering will be economical, but it can reasonably be stated that metering will be found to be economical in practically all cases, if thoroughly investigated. Take, for instance, the case of a town where there is a plentiful supply of water taken from a mountain stream at sufficient elevation to supply the town by gravity, and of sufficient purity that no treatment is necessary. Such a condition is almost ideal and could only be applied to a small town, but yet it might be economical to investigate the installation of meters to keep wastage down in order that the size of mains can be kept to a minimum and a fire fighting flow maintained, which could not be achieved if unlimited wastage is allowed to exist through an increasing number of services.

The effect of meterization on revenues is not so much to increase the total income, but to get payment for the water passing through the service, at a fair rate. This can only be determined through metering.

It is quite possible that a customer will actually consume or use no less water when the service is metered than he would on a flat rate basis, but there is no question that the wastage would be cut down, with the result that the water company or department will get more revenue per 1000 gallons of water put through the service. Waste and leakage are the bugbears of the water department and can always be interpreted as wasted or lost money.

The writer knows of a case where as much as 300,000 gallons of water per month passed through a domestic service, and this only a stand pipe in the yard, which water was not consumed of course. For that water the municipality received $0.95 or at the rate of 0.32 cent per thousand gallons. Meterization changed this and although the consumer's needs are entirely satisfied and his bill is only $1.00 per month the water passing the service has been cut to below 2000 gallons per month and the water department is getting paid for what does pass.

When flat rate services are in effect and the water department attempts to make a house to house canvass to detect leaks and other wastage of water the inspector is continually met with all kinds of excuses and after he leaves, there is, as a rule, very little further effort made to stop leaks or to prevent wasteful usage of water and the inspector's time and effort is generally pretty much wasted. When meters are installed such inspections are not necessary.

In making rates for flat rate service all types of service must be

enumerated and the number of spigots and other points of water usage determined. This is impossible to keep up with and in many cases where new points of usage are installed they are not reported to the water department. When a meter rate is made up it applies to all consumption, no matter where it is used, or how many fixtures are installed.

When wastage is cut down pumping equipment and treatment plants can be of smaller capacities and pumping and operating costs can be reduced. Although the total revenue produced by the plant might not be any more than when on flat rates, the charge for capital account and operating costs is reduced and the net revenue increased, which might in turn be reduced with resultant reduction of rates.

By no stretch of the imagination can it be regarded as sound to treat water, perhaps spend money for pumping it and then let it flow down to the sewer, without serving any useful purpose, and without being justly paid for. This is continually being done when water is served through unmetered services.

One of the objects of metering is to check up on losses and this can be done effectively only if all services are metered and then by comparison with the readings of a master meter a check up of losses and unaccounted for water can be made. This brings up the question of whether schools, churches, cemeteries, etc. should be metered and the water service paid for. When the consumptions at these places is reviewed, and in a great many of them considerable wastage occurs, it is readily brought out through metering that appreciable quantities of water pass the meters and the question is readily answered that this type of service should be paid for. In a good many of the municipally owned plants an increase of revenue can be gotten through this means. Privately owned concerns charge for all alike as it is regarded as no more than sound business.

In order to get the maximum benefit from meters it is essential that all water going into the premises be metered. This means that the meters must be properly set so that they are readily accessible, protected from frost and easily read and then tested to maintain accurate registration. Reading of meters monthly promotes better results as stoppages are detected more frequently which can be corrected and revenues maintained.

In times of drought, when people will naturally use more water for household purposes, sprinkling lawns and gardens, washing porches, etc., if meters are installed, a noticeable increase in revenue can be

noted. In one case, during the 1930 drought, this increase was as much as 10 to 12 percent, whereas a neighboring town, with less population, and with a larger reservoir but with unmetered services, suffered a shortage and was forced to curtail usage.

When meters are installed this extra consumption will produce more revenue for the water department and with a properly made up rate schedule it will be profitable for the water department to take on the extra load, but with unmetered services the water department will be called on to supply more water, under perhaps more difficult conditions, and get no more revenue for it. In fact, the revenue per 1000 gallons would be less.

It is pretty well established that water meters will under-register more often than they will over-register and even when a meter may be stopped entirely, due to some wedging of the disc or other moving parts, the customer may have no interruption of service. On high flows a meter may register a little higher, but it is seldom that the draft on a domestic service is heavier than two gallons per minute so that there are very few times when a meter will over-register. In order to obtain maximum revenues, therefore, it is quite necessary that meters be tested frequently.

The only fair and equitable way to charge for water service, from which the largest part of the revenue of the water department is derived, is that which is based on the amount consumed and the only way in which this can be determined is by metering. The only way that an equitable schedule can be set up is by first knowing what it costs to produce the water and then to distribute this cost equitably among the consumers thereof. The only way to do these things is through the agency of meters, which it can be seen play no small part in the economic side of water works operation, namely in the regulation of consumption and revenues.

Virginia law makes it mandatory that municipal projects, financed by revenue bonds, be made self-supporting within five years after completion of the project or the bonds will automatically be classed as general obligation bonds. One hundred percent metering will do its part to keep the revenues and operating expenses of revenue producing water works in balance so that the bond limits of the city or town are not exceeded. This is a very important part of the economical operation of the water works.

No attempt has been made in this paper to show actual figures where input and revenue adjustments were made through metering,

but it can be safely said that input can be cut down as much as 50 percent in some cases, with corresponding reductions in treating and pumping costs and figures can be obtained so that a scientific rate structure can be set up which will produce the correct revenues required.

Schedules of what various cities have done in cutting down wastage and adjusting rates may be obtained from some of the meter manufacturers or from the Water Meter Institute at Washington, D. C.

(Presented before the Virginia Section meeting, July 13, 1934.)

METHODS OF METER READING, BILLING AND COLLECTING

By Hugh B. Rice

(*City Collector, Staunton, Va.*)

Beginning with those stormy sessions in the City Council prior to the adoption in January, 1906, of an ordinance providing for the change from annual to semi-annual assessment of water tax, there has been a gradual change in Staunton, Va., to its now present system of monthly billing of all water consumers. Records show that the first hint of this "drastic change" was incorporated in a report of the Water Committee about a year before, when it was proposed to install several meters for experimental purposes. This report called for "a gradual and complete installation of meters for all consumers." With $150.00 to start with, the committee in April, 1906 began installing meters until in 1923 the system was completely metered, including schools, all public building, parks and even the drinking fountains on the streets.

The last step, that is, from quarterly to monthly billing, was hastened by the increasing loss of bad accounts by the inability to hold the property owner responsible for the tenants' bills. The City had been reading meters monthly since 1927 so that it was matter of stepping up the billing and collecting system. The economic distress made it apparent that some relief should be offered to the consumer, and this has been proven by the absence of long cut off lists. More persons have $1.00 each month than $3.00 every three months. The City also has the use of one third of this money for two months and another third for one month.

At the same time, other changes were made. Collection was placed in the hands of the City Collector, a staggered system of reading, billing and collection was set up, the method of reading was changed, and meter settings were improved upon, all of which were timely and have proved to be of benefit to the City.

Before discussing the system established, it might be well to outline the duties, other than those in the Water Department, which each person along the line has to perform. Staunton, whose population is around 12,000, usually has several jobs for each employee.

In the case of the City Collector, his office also collects delinquent city taxes and miscellaneous bills for departmental services and rents. The billing clerk is Clerk of the Council and Auditor. The Superintendent of the Water Department is Fire Chief and City Electrical and Building Inspector. The meter reader also repairs and tests meters, while the delivery man delivers City checks, purchase orders, Council communications and other notices requiring personal service. All combinations of duties seem to be logical from the standpoint of service in a smaller city.

READING

A schedule was worked out for the 2700 accounts (divided into fifteen route books) as shown in table 1.

The meter route books contain 125 to 225 leaves and are routed so that the reader may begin either near the City Hall or at the end of

TABLE 1

BOOKS	READING	BILLING	DELIVERY	PAYABLE	2ND NOTICE	CUT OFF
1–5 inc.	Feb. 1– 6	Feb. 6– 7	Feb. 8–10	Feb. 20	Feb. 22	Feb. 28
6–9	Feb. 10–15	Feb. 16–17	Feb. 18–19	Feb. 1	Mar. 3	Mar. 9
10–15	Feb. 20–25	Feb. 27–28	Feb. 28–Mar. 1	Feb. 11	Mar. 13	Mar. 19

the previous route. Ample room has been allowed in the books for additions due to building up in the newer sections of the City.

The meter book leaves are arranged with space for two years' readings on each side. The buff color used reduces the glare considerably, saving the reader much eye strain experienced in adjusting the eye from looking down at the meter and then at the book. Besides the columns show monthly reading, consumption and amount of bill. Space is provided for date meter was set, reset and location. The size, make and number of the meter provide the reader with a check to avoid misreading. The type of service and date of test of meter may also be noted on the top. On the bottom of the leaf is shown the name of owner, location, account number and space for four tenant names together with dates each moved in and out and for any remarks such as where tenant moved from or to.

The meter reader's duties are first to read the meter correctly and make the subtraction to determine the monthly consumption.

Should this show the consumption to be in excess of the average for the past several months, an abnormal notice is left at the property. If no consumption is shown for the past month, a note is made of this fact and later he checks up to see if the meter has stopped. If so it is repaired and tested. He also reports uneven or dangerous places in street and sidewalks, especially around meter boxes. In the event a meter cannot be read, the meter reader reports the fact on a work order, stating what must be done before the meter can be read. The reading is secured before the bill is sent out as no averaging of bills is allowed. A bill for the exact reading is rendered and if any adjustment is to be made for an excessive bill it is done later.

BILLING

Upon receipt of the completed book, the billing clerk computes the amounts and makes out the bills. The "stub office copy" system is used and three copies are made at the same time. No. 1 is the white copy which goes to the consumer. No. 2 is the office copy and is yellow. No. 3, salmon colored copy, is used as a second notice or it may be stamped and used as a receipt in the event the consumer fails to have his first bill when paying. The billing clerk is able to handle 500 to 800 bills in a day, including addressographing the names on the bills. All arrears are posted on the bill by the Collector's office after which the yellow or office copies are put together.

COLLECTING

The bills are delivered by a regular employee, not only to affect a saving in cost, but to keep up with tenant changes. The delivery man rings the door bell and if it is not answered within a reasonable time, the bill is placed under the door. In each case an attempt is made to deliver the bill to a responsible person. Vacant houses and tenant changes are reported by the delivery man to the Collector's office where a work order is issued to remove meter or a "sign-up notice" is sent to the new tenant.

In setting up the office system about a year and a half ago, simplicity was the key word. As we insist that the consumer bring his bill when paying, it is merely a matter of stamping the bill and stub, removing the stub which together with the money is placed in the cash drawer. At the end of the day the money is checked against the total of stubs. The next morning the office copy is stamped "paid" and a total is taken of all stamped copies. This total is

checked against the stub total for accuracy in posting. The paid copies are then pulled out and put below the "paid" spacer. A bound book is used to show a summary of daily collections. A report of all collections is made to the City Council at the end of each month.

When a bill is not paid within ten or twelve days after it is delivered, either a second notice is sent or a phone call reminds the consumer that he has overlooked his bill. When it is necessary the Collector issues a work order to the Water Department to remove meter for non-payment. A similar work order is issued to turn on or reset meter upon payment of the bill and the fifty cents "turn-on" charge.

The work order referred to is in perhaps as simple form as can be arranged. It is made out in duplicate and numbered so that the duplicate (blue copy) can be filed and referred to until the completed original is returned to the Collector's office. The left half states "work to be done" and the right "work done." Instructions may be made merely by drawing a circle around the words "meter" then "reset," "remove" or whatever is to be done. Ample space is provided for writing in any instructions other than those printed thereon. Similar instructions for service, main or valve repairs or renewals can be issued so that there is little question as to the meaning of the order.

On the right half of the work order the Superintendent states what was done, showing meter number, make, size and reading, depth of pipe and the distance main or service is from property line. This information is plotted on the water maps. Space is also provided for report of excavation and account to which work is to be charged. From the excavations, a list is made up for the street repair gang each week. The cost of repairs is charged against the proper account, and ledger entries are made each month so that when a new service is installed or repairs made, we have a complete cost record. All work orders, when returned completed, are filed alphabetically by street name. These are filed away in the storage vault at the end of each year.

All complaints of excessive bills or irregularities in service are handled by the Collector's office. The promptness and manner in which complaints are handled is most important to the department in building up citizen confidence. We all know that no matter how small or silly the complaint seems, it is of great importance to the person making it.

In general, complaints of excessive bills are handled in the following

manner: first, the reading is checked and if correct, the cubic foot hand is watched for a continuous leak. Then every fixture is inspected and other checks are made. Most likely something will be found wrong. Regardless of what is found, we refund all over double the average for the past year.

In order to check daily or periodic consumption, we have a register meter which makes a seven day chart. We have found this most useful in finding leaks or convincing the consumer of his daily usage of water. The accuracy of the meter at the curb can also be determined by comparing the reading of the two meters when placed in tandem.

APPLICATIONS

The applications for water service are made up in card form, and are filed alphabetically by tenant names. When the system was first set up in December, 1932, a buff colored card was used on which the name and address, as given on the addressograph list and meter book of the time, were stamped. All new applications for service inside city limits are on white cards, while those for service outside the city are pink cards. The application sets forth name of applicant, location, description and owner of property, purpose for which water is to be used, business and former address and name of former occupant. Outside users also agree to a rate 50 percent greater than the city rate and that service may also be discontinued without notice. Besides this, instructions similar to those on the work order are encircled. Space is provided for work order number, account number and name of person taking application.

When it is discovered that a tenant is occupying a property without signing for the water service, he is sent a "sign up" notice which states that if he does not sign up at once, it is assumed that he does not desire service and, therefore, the meter will be removed. This notice usually brings them in.

A work order is issued for each application, which when completed gives the size of meter, make, number, reading and date set, from which the billing clerk makes the meter book leaf and addressograph plate. The same routine is carried out when service is discontinued and a final bill rendered. All addressograph changes are also listed on a form for this purpose.

(*Presented before the Virginia Section meeting, July 13, 1934.*)

MAPS AND RECORDS OF EXISTING WATER MAINS, VALVES AND HYDRANTS

By P. H. Johnson, Jr.

(*Superintendent, Water Works, South Boston, Va.*)

Several months ago when I first took over the Water Plant of South Boston, I found that there were no accurate records or maps of the existing water system and that the only possible way of finding out the location and size of different pipes, valves, etc., was the memory of one man, the municipal plumber. Several times his memory has failed us and we have been unable to locate the necessary valves to cut off the water supply in a section of the system which contained a bursted pipe.

We have no accurate files of purchases, repairs, etc. for the system. No doubt there are many other small municipalities throughout the state which are in the same condition.

In the February, 1934, issue of "Public Works" there is an article which presents a very good plan to help us out of this situation. This plan is to make a key map of the whole system using a scale of 200 feet to the inch showing the entire system. This map should have on it all fire hydrants, valves and connections. Let this map be divided into sections and a map drawn of each section to a larger scale, for instance, 50 feet. On the maps of each section show all details such as the exact location of mains, service taps, valves or any other desired information concerning the system. When these maps are drawn and ready to file, mark on the key map the exact location in the file of the section map. For example, if you are filing the maps in drawers, mark on the key map the number of the drawer and the number that the map is in the drawer such as, D-12, D designating the drawer and 12 as the 12th map.

This system would simplify the method of locating the desired information as for the layout of the system. In filing the other data, such as purchases and repairs for the system, a card index would help materially, indexing it accordingly to every possible head under

which that particular thing could be filed. This would save much time in looking up the desired information in your files. This sounds like too much work and time lost, but it could be cut down to a certain extent by standardization of equipment.

(Presented before the Virginia Section meeting, July 12, 1934.)

THE DETERMINATION OF AMMONIA IN THE FIELD

By W. S. Davis and C. B. Kelly

(From the Division of Laboratories and Research, New York State Department of Health, Albany, N. Y.)

The popular use of the ammonia-chlorine treatment of water has made desirable a quick and accurate field method for the determination of free ammonia. A recent article by Hulbert (1) emphasizes the advisability of maintaining laboratory control, at the plant, of ammonia when used with the chlorination of drinking water. Fletcher and Link (2) have demonstrated the necessity of regulating carefully the ammonia content of swimming-pool waters.

Both the direct Nesslerization and the distillation procedures as described in Standard Methods for the Examination of Water and Sewage (3) require so much apparatus and are so time-consuming that, without modification, they can not be conveniently followed in the field. The use of Nessler tubes is not to be recommended in any case, because of their fragility and the difficulty in packing them.

According to the direct Nesslerization procedure given in the Standard Methods, the precipitation of magnesium and iron salts by the sodium hydroxide present in the Nessler reagent has been avoided by pre-precipitation with sodium hydroxide, and settling has been assisted with precipitated copper hydroxide. Color and turbidity are carried down with this precipitate. The procedure is time-consuming and has not always resulted in a clear, colorless, supernatant liquid. Wattenburg (4) recommends the addition of sodium-potassium tartrate (5 cc. of a 30-per-cent aqueous solution to each 100-cc. sample) before the Nessler solution is added, in order to avoid the precipitation of magnesium and iron salts. Using both sea water and various hard fresh waters, we have confirmed his results. With this modification, direct Nesslerization is, we feel, the method of choice for field use.

Because of their convenient size and strength, two-ounce, French square bottles of clear white glass, with Bakelite screw caps, were selected as containers for the samples and the standards. The

bottles are 105 mm. high, 35 by 35 mm. wide outside, and approximately 28 by 28 mm. wide inside.

PREPARATION OF PERMANENT STANDARDS

The permanent standards described in Standard Methods are obviously not suitable for use when comparisons at a depth of 28 mm. are made, since they are standardized for the 200-mm. Nessler tubes. Special permanent standards for use at the 28-mm. depth were prepared by adding a sufficient amount of the standard potassium platinic chloride and cobalt chloride solutions to distilled water to make a solution the color of which is of the same intensity and shade as that of the comparable Nesslerized ammonium chloride standard. Comparisons were made by looking through the sides of the bottle placed on a white surface, at another white surface. The formulae for these special standards are given in table 1. The specified amounts of platinum and cobalt solutions are added to distilled water and diluted to 50 cc. Amounts of ammonia over 1.4 p.p.m. should not be determined because of the danger of precipitation of the ammonia Nessler reagent complex. For this reason, formulae for standards higher than 1.4 p.p.m. were not evolved.

TABLE 1

Formulae for the preparation of permanent standards for the determination of ammonia

AMOUNT OF AMMONIA NITROGEN		VOLUME OF SOLUTIONS	
		Potassium platinic chloride	Cobalt chloride
mg. per liter	*mg. in 50 cc.*	*cc.*	*cc.*
0.08	0.004	4.7	0.1
0.2	0.01	7.7	0.2
0.4	0.02	12.8	0.2
0.6	0.03	18.2	1.0
0.8	0.04	24.5	1.5
1.0	0.05	30.5	2.5
1.2	0.06	36.0	3.2
1.4	0.07	42.0	3.5

The Standard Methods (3) contain the following statement relative to the formula for permanent standards.

"The values given in the table are approximate: actual equivalents of the standards thus prepared will differ with the quality of the Nessler reagent and

the color sensitiveness of the analyst's eye. They should be compared with Nesslerized ammonia standards and the tint modified as necessary. Such comparisons should be made for each Nessler solution and checked by each analyst."

Obviously, this precaution also applies to the special formula given above.

The following method, was, therefore, adopted for use in the determination of free ammonia by direct Nesslerization:

Add 2.5 cc. of a 30-per-cent ammonia-free sodium-potassium-tartrate solution to 50 cc. of the water to be tested; mix by shaking and add 1 cc. of Nessler solution. Allow to stand for at least five minutes and compare with permanent standards. If the amount of ammonia present is greater than that of the highest standard, make appropriate dilutions with ammonia-free water. Turbidity and color can be compensated for by viewing the standard through an extra bottle containing the sample to which has been added the 2.5 cc. of sodium-potassium-tartrate solution. A bottle containing distilled water should be placed behind the sample to be tested in order that observations may be made through equal depths of liquid.

SENSITIVITY AND ACCURACY IN THE PRESENCE OF COLOR OR TURBIDITY

The possible error in estimating the ammonia content of samples having any appreciable amount of color or turbidity was also considered. To ascertain the extent of these errors, a series of standards was prepared in which the ammonia nitrogen varied in steps of 0.02 parts per million. These were placed in the two-ounce bottles previously described. A series of color and turbidity standards, prepared according to Standard Methods, was placed in similar bottles. Color ranged from 5 to 100 p.p.m., and the turbidity from 5 to 150 p.p.m. These color and turbidity standards were individually superimposed on the ammonia standards and determinations were made by comparisons, by several observers, to determine the extent of error due to this interference. Although the color standards are designed for use at a 200-mm. depth, the error that resulted from reducing the column compared was found to be very slight, when the colors were of this intensity, and errors in the determinations due to this were considered to be negligible. These standard colors have the advantage of being easily reproducible at another time or by other observers.

In the range of 0.08 to 0.2 p.p.m. of ammonia, it was found that the presence of color or turbidity rendered the procedure unsatisfactory as an accurate quantitative measure. In the absence of color or

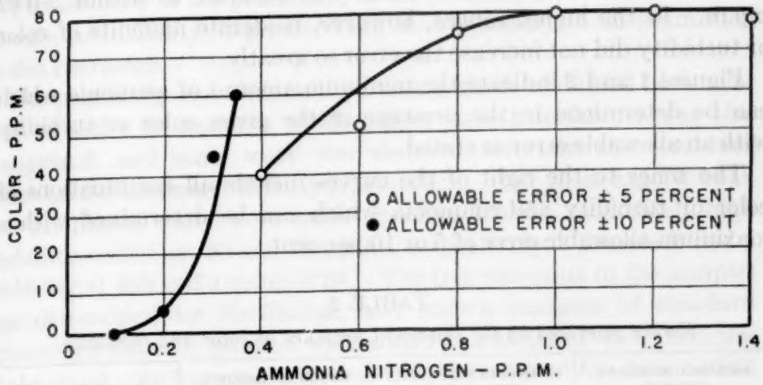

FIG. 1. MINIMUM AMOUNT OF AMMONIA WHICH MAY BE DETERMINED AT THE GIVEN COLOR WITH ALLOWABLE ERRORS OF 5 AND 10 PERCENT

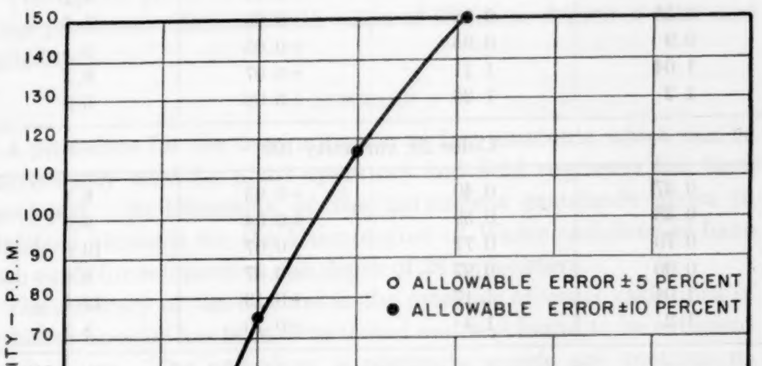

FIG. 2. MINIMUM AMOUNT OF AMMONIA WHICH MAY BE DETERMINED AT THE GIVEN TURBIDITY WITH ALLOWABLE ERRORS OF 5 AND 10 PERCENT

turbidity, the method in this range was accurate to within ±0.02 p.p.m. In the higher ranges, however, moderate amounts of color or turbidity did not increase the error so greatly.

Figures 1 and 2 indicate the minimum amount of ammonia which can be determined in the presence of the given color or turbidity with an allowable error as stated.

The zones to the right of the curves include all combinations of color or turbidity and ammonia which can be determined with a maximum allowable error of 5 or 10 per cent.

TABLE 2

Errors produced by the combined presence of color and turbidity

AMMONIA NITROGEN PRESENT	AMMONIA NITROGEN DETERMINED	ERROR IN AMMONIA NITROGEN	PER CENT ERROR
	Color 45, turbidity 50		
p.p.m.	*p.p.m.*	*p.p.m.*	
0.37	0.4	+0.03	8.1
0.55	0.58	+0.03	5.5
0.9	0.95	+0.05	5.5
1.04	1.11	+0.07	6.3
1.2	1.26	+0.06	5.0
	Color 20, turbidity 100		
0.37	0.40	+0.03	8.1
0.55	0.59	+0.04	8.0
0.70	0.77	+0.07	10.0
0.90	0.97	+0.07	6.6
1.04	1.17	+0.13	12.5
1.2	1.3	+0.10	8.3

Any amount of ammonia greater than 0.3 p.p.m. can be determined in the presence of color up to 100 with a maximum allowable error of 10 per cent. The zone of 5 per cent maximum allowable error includes practically all combinations of ammonia and color which might be found in most surface waters.

Turbidity is responsible for greater interference. It will be noted that the zone of 5 per cent error includes turbidities up to 38 at 0.8 p.p.m. of ammonia. Concentrations of ammonia greater than 0.8 p.p.m., in the presence of turbidity up to 150, can be determined with an allowable error of 10 per cent or less.

The accuracy of the procedure, in the presence of moderate degrees of color or turbidity, is greater than that necessary in an estimation of this character.

The possibility of encountering a water which contained both color and turbidity in amounts which might cause interference was also recognized, and some work was done to ascertain the combined effect on the accuracy of the determination. For these experiments, two samples of water were used. Sample A had a moderately high turbidity and color, 50 and 45 p.p.m., respectively. Sample B had a turbidity of 100 and a color of 20. The free ammonia in the samples was determined by distillation, and known amounts of standard ammonium chloride solution were added to a series of 50-cc. samples of the water; the free ammonia was then determined by the modified method and tbe results were tabulated, after the readings had been corrected for dilution by the reagents added. These results are given in table 2.

The figures given in this table are in substantial agreement with those previously obtained with water of the same degree of color and turbidity.

SUMMARY

A procedure for the determination of free ammonia which can be conveniently used by plant operators and field engineers has been developed. Modifications of the permanent standards given in Standard Methods for the Examination of Water and Sewage have been made for comparison at a depth of 28 millimeters.

The accuracy of the method in the presence of usual variations of turbidity or color has been determined and was found to be sufficient for field use. The procedure is relatively simple and requires no elaborate apparatus.

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TASTE CONTROL OF WATER SUPPLIES

By R. A. Irwin

(Assistant Chemist, Department of Health, Ontario, Can.)

Taste and odor problems in municipal water systems have long been a source of trouble to those whose responsibility it is to supply safe and palatable water. Consumers may be assured that a water is bacteriologically safe, and it may be clear and sparkling, but if it has the slightest suggestion of a taste, complaints will pour in to the operator. Not only is he accused of being responsible for such condition, but he is told by the citizens that the water cannot be safe if it is in that condition, and that taxes are not paid for the privilege of having objectionable water. If the taste is very disagreeable, it may carry with it a health menace, for many consumers are likely to turn from the municipal supply to unsafe yet palatable sources for drinking water.

The causes of tastes may be divided into three or more main headings:

1. The presence of organisms or vegetable matter in the raw water. This includes a very wide field from decomposing vegetation to the countless algal growths whose intensity varies with the period of the year. This type of taste problem is common in Ontario where many of our supplies are drawn from marshy, highly colored sources, with a large variety of algae. These tastes are described variously as weedy, grassy, fishy, mouldy, and peaty.

2. The second source of offensive taste is from industrial waste and domestic sewage. This source is difficult to control and drastic steps are necessary to prevent undue contamination of the water supplies. The most common taste encountered from these sources is that of the phenolic or iodoformic type; this is greatly intensified where the water is chlorinated. Chlorophenol tastes are common and quite disagreeable. The so-called chlorinous taste which the consumer claims is the result of too high a chlorine dosage is often caused by the chlorination of a minute amount of some waste present in the supply. In Ontario, some of the larger centres, obtaining water from the different rivers and lakes are troubled with this kind of

problem. With ever increasing industrial activity the probability of taste producing wastes in these surface waters becomes more and more likely. Only careful control and treatment of industrial wastes will prevent this taste from becoming a grave problem to the waterworks engineer. In the United States, where these industries are so much more numerous, it has been necessary to require them to treat the waste liquors before entering the stream. If an accident occurs and a spill goes to the stream the State Health Department is notified immediately and cities below the plant outfall are warned of the presence of phenols or other wastes in the river. Steps then can be taken to prevent the tastes getting to the consumers. Obviously this is the cheapest means of preventing bad tastes, but it cannot always be carried out.

3. The third source is from dissolved gases such as hydrogen sulphide in the water itself. This is usually an unimportant source and can generally be corrected by simple aeration or by chlorination.

DEVELOPMENT OF METHODS

During recent years spectacular advances have been recorded in the treatment of tastes. Ten years ago, waterworks engineers were almost in despair at the increasing occurrences of tastes in water supplies at some time or other during the year. Various methods of control were attempted without much success. Such methods as were successful were often very expensive.

Today, it is claimed that there is no taste which cannot be removed from a water supply, and generally at a reasonable cost. The advance which has been made in these ten years is an achievement which marks a fascinating chapter in the history of waterworks development. A great deal of credit is due to the painstaking work done in many waterworks laboratories to prove the efficiency and usefulness of the various methods. A great deal of work yet remains to be done before this problem is completely conquered but the earlier and more difficult work at least is completed.

The most common treatments for taste and odor removal may be listed as follows:

(1) Aeration
(2) Pre-chlorination
(3) Super chlorination and subsequent de-chlorination
(4) Ammonia chlorine
(5) Activated carbon

(6) Potassium permanganate
(7) Ozone
(8) Copper sulphate
(9) Fullers earth or bleaching clay

Aeration

Aeration has been common practice for years and is used in many instances in connection with filtration plants. The various types include the cascade and spray methods. In the treatment of tastes the method is seldom a cure except where the cause is from dissolved gases such as hydrogen sulphide, but it often alleviates serious tastes due to organic growths. Where dissolved oxygen is very low, the value can be raised by aeration and thus the condition of the water is improved. It is not usually a successful method for treating chlorophenolic and other tastes due to industrial pollution.

Pre-chlorination

Pre-chlorination is practised in plants for a variety of purposes. In Ontario, this method has not been found particularly effective in the prevention of tastes, although it is the method of chlorination in many instances because of the use of pressure filters. In pre-chlorination the larger amount of chlorine employed may assist in the oxidation of taste producing compounds. This increased amount is not large enough to be considered as super-chlorination. In a report by the Committee of the American Waterworks Association on the Control of Tastes and Odors in Public Water Supplies for 1932–33 (1) it is stated that especially in New York State this method is used more than any other single method for combatting tastes. In a total of 332 plants in the various States studied 86 find this a successful method of taste treatment.

Super chlorination and subsequent dechlorination

This method of treatment consists of a high dosage of chlorine, which after a period of contact is dechlorinated to the usual standard of chlorine residual. The largest and most successful use of this process is at Toronto, where it has been used to remove chlorophenol tastes since 1926. At Toronto the dechlorination is effected by the use of liquid sulphur dioxide fed by machines similar to chlorinators. Howard (2) reports that practically all tastes are removed by this method, and the cost is not found to be excessive. Other sulphur

compounds such as sodium bisulphite in solution have been used as dechlorinating agents. This method is not extensively used as yet in waterworks practice. Dechlorination with carbon will be described later.

Ammonia chlorine

This method consists, briefly, of the introduction of ammonia to the water either in the form of gas, which is readily soluble, or by means of a solution of an ammonium salt. After proper mixing the chlorine is introduced and reacts with the ammonia to form a chloramine. Both the mono- and dichloramine are formed; the proportion of each depends on various factors such as pH, temperature, and ratio of chlorine to ammonia.

Theoretically, using ammonia gas, the ratio in order to obtain the mono-chloramine is 4 of chlorine to 1 of ammonia. In practice the usual ratio is 3:1, or sometimes an even higher ammonia dosage. Ammonia is a good food for organic growths and thus it should be added only far enough ahead of the chlorine as to guarantee good mixing. It must be remembered that if a salt such as ammonium sulphate is used the ratio is not 3:1 but 3:4. Ammonium sulphate is only approximately 25 percent ammonia.

This method of treatment does not remove the taste producing substances, but prevents the formation of disagreeable chloro compounds. Race (3) at Ottawa, 1918, was one of the pioneers in this field. This method of treatment was used at Ottawa until the installation of the new plant in 1932.

A great many investigators have done work on the sterilizing efficiency of chloramine. Holwerda (4) pointed out the possibility of a lag in the sterilizing action as contrasted with chlorination. While numerous articles have been published both supporting this contention and disagreeing with it, neither side seems to be able to show conclusive proof. Ellms (5) disagrees, and claims it is purely a problem of proper mixing. Baker and Schmelkes (6) report work which confirms Holwerda's statement and maintain as he does that the pH has a great deal to do with the velocity of sterilization, it being slower at a high pH. Considerable work has been carried out in our own laboratories without any marked appearance of a lag, regardless of pH or temperature. Other investigators state that the velocity varies as the ratio of chlorine to ammonia is varied. Obviously if this is so it would be more rapid the higher the chlorine content of

the compound. Braidech (7) and also Gerstein (8) show that while there may be a lagging in the action, it is easily overcome by an increased period of detention.

In spite of this controversy the advantages of the ammonia chlorine process have been well proven. It is an effective prevention against tastes, particularly those of the chlorophenol type. Chloramine has marked stability, and is used to prevent after growths. It is possible to carry a high residual without producing chlorinous tastes or odors, and thus a residual may be carried throughout for protection from taste producing growths in open reservoirs and dead-ends of the distribution system.

In some cases tastes are due only to growths in the system and not to the reaction of chlorine with substances in the raw water. It has been found that if the water is chlorinated and good sterilization is obtained and then ammonia is added to form the chloramine with the residual chlorine, this residual effectively kills after-growths throughout the system. It is not necessary with this post-ammoniation to consider the lag in sterilization.

These advantages are so great that the increase in the use of this process in the last three years has been enormous. In the United States on January 1, 1930, there were only five installations using chloramine. On May 25, 1931, there were one hundred and ninety installations (Berliner 9). Since then the number has rapidly increased until in 1933 in a study of twelve states, 35 percent of the supplies being treated for taste were using this method.

It would seem that when the ammonia chlorine process is used it is necessary to maintain a sufficient period of retention to ensure effective action on the product of the plant before it reaches the consumer. Various retention periods have been suggested, but the minimum period for safety is generally thought to be two hours. If a longer time is possible, so much the better.

Activated carbon

This is a measure which has advanced very rapidly in the past few years. The purifying properties of carbon have been known and used in various industries for many years, but only in the last few years has it been used extensively in waterworks treatment. Unlike the chloramine treatment, the reaction constitutes complete removal of the taste-producing substances by adsorption. The adsorptive powers of properly activated carbon are very great. Its early use was

in carbon filters built of granular carbon through which the water was passed. From time to time it was necessary to reactivate the carbon with hot air or steam. This method had a high initial cost and thus was not very attractive.

Since 1929 powdered activated carbon has been used, and as it requires practically no extra equipment, and since it is not necessary to use excessive amounts, it has become one of the most important factors in the treatment of all types of tastes.

The carbon is fed either by a dry feed machine with a water ejector, or by means of a solution in which the carbon particles are kept in suspension by agitation. In small plants and for emergency purposes, a barrel with an agitating device and a constant discharge has been found very satisfactory. The question as to point of application of the carbon depends on the type of trouble which is to be corrected. In emergency cases it is so introduced as to rapidly ensure the presence of carbon throughout the system. The usual methods are to feed:

(a) To the raw water
(b) To the mixing tank either with the chemicals from one dry feed machine or separately.
(c) Coagulation basin, either at the entrance or in a position a short distance from the entrance.
(d) To the effluent from the settling basins or immediately on top of the filters.

Obviously, in using the first method the dosage would necessarily be quite high, and for that reason, except where the tastes are excessive, it is not generally used.

Frequently the cause of taste in the water is due to the putrefaction of the sludge in the coagulating basins. This often causes a disagreeable odor around the plant. It seems definitely established that the addition of carbon in quantities of 0.1 to 2.0 p.p.m. will stabilize the sludge to such an extent that it does not putrefy. It is reported that it tends to draw together "pinhead" floc and thus the minimum alum dosage may be reduced. It is also said that good flocculation can be obtained over an increased pH range. When the carbon is added in this manner and pre-chlorination is practised, it is found that, contrary to expectations, the carbon does not adsorb the chlorine. This is an unexplained phenomenon. It has been found that if there is not an excess of carbon used this is always true. Dosages of 2.0 p.p.m. do not noticeably reduce the chlorine residual. When

the carbon forms a surface on the filters, however, the chlorine is effectively removed in passing through them. A commercial activated carbon manufacturing company states in this connection ". . . . Passing through the filter, on which of course a small amount of non-settled carbon is deposited, complete de-chlorination is effected and the effluent exhibits no chlorine demand." From these statements it would appear that only when carbon is present in comparatively large quantities, such as on a filter, does it adsorb the chlorine. Thus a super-chlorination process may be used and the water from the filters will be de-chlorinated by the carbon present.

In adding carbon immediately ahead of the filters, some operators have found a decided lowering in filter runs. However, in many cases a small dosage of carbon has been found to be very effective and the filter run is not materially reduced.

In 1929 only a very few practical experiments were being carried out in the use of carbon. Since then the advance has been very rapid, and last year the committee on tastes, mentioned above, sent out a questionnaire to over four hundred plants using carbon for taste removal. Some of the data returned is of particular interest.

Of the number of replies, 50 percent were feeding carbon in the coagulation process, and the other 50 percent either on top of or just ahead of filtration.

Where the addition was in the coagulation process, 60 percent reported better coagulation, while the remaining number did not; 69 per cent reported an increase in the stability of the sludge, 13 percent did not, and the remainder did not reply to the question. Approximately 33 percent used less coagulant.

Where the addition was just ahead of the filters there were more plants reporting no decrease in the filter runs than those who did experience a decrease. Some of these plants pre-chlorinated and some also pre-ammoniate.

In reply to the question of dosage 69.5 percent of those answering the question used less than 2.0 p.p.m. and 25 percent used less than 0.7 p.p.m. Only 8 percent used more than 4.0 p.p.m.

In answer to the question "Has powdered activated carbon corrected tastes and odors?"

121 plants reported "Yes"
15 plants reported "Partially"
5 plants reported "No"

The remaining plants did not answer the question.

From this brief summary it can be seen that carbon is proving to be a very effective method of treatment for all types of tastes and odors.

Potassium permanganate

Potassium permanganate was one of the earliest methods used in taste problems and for many years seemed to be one of the few satisfactory means of even *partially* successful taste control. Since the advent and success of other methods of treatment, however, the use of potassium permanganate has diminished. It has not been very successful in comparison with other methods though it is still used by a few plants. In some cases where it is used a bitter astringent taste is frequently left in the water.

Ozone

Ozone is not extensively used on this continent as a sterilizing agent. It has been definitely known, however, for some time past that its efficiency in sterilization is equal to that of chlorine. It also reduces color in a water to a great extent and effectively prevents taste in most cases. An experiment was carried out at Lindsay in 1909 by the Department of Health of Ontario and this process was found unsatisfactory. However, the report states that the lack of success was due entirely to mechanical difficulties; it was nearly impossible to obtain efficient mixing so that the ozone could come into contact with all the water. During 1931 the Metropolitan Water Board, in England, carried out an experimental test and found it entirely satisfactory. It is planned to do further work on a plant scale and success is anticipated without too high a cost.

In France (10) the process is extensively used. Paris sterilizes 60,000,000 gallons per day with ozone and in 1930 54 installations were in satisfactory operation throughout that country.

It is possible that with the cheap electric power in Ontario this method may be given more consideration in the future (11).

Copper sulphate

The use of copper sulphate is not in a true sense a taste treatment, but it is very effective as a taste preventive. It cannot be used satisfactorily in any place in a system except in open reservoirs. In problems where the taste is due to heavy algal growths, in these

reservoirs the growth can be easily killed by introducing copper sulphate. Practically all residual copper is removed in the coagulation process.

Fullers earth

The use of Fullers earth and various bleaching clays has not been practised extensively.

EXTENT OF TASTE CONTROL

To show the extent of use of the various methods described above the following figures are taken from the report of the Committee on Control of Tastes and Odors in Public Water Supplies previously mentioned, covering the practice in twelve states: Of the 332 plants studied—

Percent	*Number*	*Treatment*
35.2	117	Ammonia chlorine
1.2	4	Super and de-chlorination
25.9	86	Pre-chlorination
0.9	3	Potassium permanganate
0.6	2	Granular activated carbon
34.6	115	Powdered activated carbon
0.6	2	Fullers earth or bleaching clay
0.3	1	Ozone

Some of these plants use a combination of more than one method.

ONTARIO TASTE PROBLEMS

The problems confronting the waterworks operator in Ontario are somewhat similar to those in the United States. Most of the complaints occur in the summer, and a large number are due to algal growths of various types. The season of their growth marks the taste occurrence.

Toronto continues to use super chlorination with very effective results against phenolic tastes which are likely to occur at any time.

Ottawa has discontinued using chloramine, but uses activated carbon in the new filter plant. They have been troubled with taste due to sludge putrefaction, rather than tastes in the raw water. Carbon has been delivered as an aqueous suspension to the mixing chambers at the rate of approximately 1.8 p.p.m. The treatment is effective in keeping the plant in a 'sweet' condition. It is not found that the carbon removes the natural tastes from the water but these are not very pronounced.

Brantford has been using activated carbon during spring and summer months to treat tastes of a fishy nature. Dosage of 1.2 p.p. m. is added to the raw water before entering the sedimentation basin. This serves to prevent bad odors in the sedimentation basin, but only partially removes the taste.

At Guelph successful results have been obtained in the use of chloramine to control a phenol taste derived from a wood stave pipe line. Ammonium sulphate and chlorine are applied at a point about 2 hours ahead of the pumps.

At Wallaceburg, the control of tastes has been found effective by the use of chloramine. This method has been applied since April, 1931.

At Chatham, chloramine has been in use since June, 1931, for the correction of weedy tastes. The results have been quite satisfactory.

At Napanee, carbon is used whenever taste becomes evident, when a heavy dose is added, and gradually reduced and maintained at about 0.7 p.p.m. This is added to the influent of the coagulation basin. The superintendent reports that as a result the sludge in the coagulation basin does not putrefy and that tastes are completely removed.

Orillia uses 1.0 p.p.m. of carbon during the summer months to remove algal tastes from the water. It is reported to be very satisfactory.

New Toronto has been using activated carbon successfully for some years. At this plant it is in use throughout the year. It is fed at the rate of 1.4 p.p.m. shortly after the alum has been introduced. Mr. Hugh Thomas has developed a very satisfactory dry feed arrangement for applying the carbon. It is reported no occurrence of taste has taken place since carbon has been used.

Huntsville uses activated carbon on rare occasions when the taste problem becomes acute. Fairly satisfactory results are obtained.

During the winter of 1930–31, the Border Cities water supply was seriously troubled with objectionable medicinal tastes. Pre-chlorination had been used and was discontinued, but this had no effect, and so the treatment was resumed. Finally, it was decided to try chloramine and within twelve hours an improvement was observed. A month later the ammoniation was stopped and the taste immediately recurred. Chloramine treatment was then continued and has been used to the present with very satisfactory results. During the year 1933 the average amount of ammonium sulphate used was 2.6

pounds per million gallons, with 1.6 pounds per million gallons of chlorine. The added cost in using ammonia was quite low, being approximately 8 cents per million gallons which covered all handling.

The Thistletown Hospital for Sick Children has been using activated carbon for the removal of bad tastes during the summer months. During the past winter when the river was frozen over they were troubled with medicinal tastes which did not seem to be removed by the carbon. They have been experimenting with chloramine as well as with carbon in order to solve this problem.

Hespeler has been troubled with a serious growth of crenothrix in the mains and in the reservoir with very objectionable taste resulting. The supply is from artesian wells, but does not have a high iron content. The dissolved oxygen is rather low, however. During the past summer a chlorinator has been installed and it is hoped that in this way the growth may be controlled. High dosages of chlorine have been flushed through the system from time to time.

Belleville has had a slight taste problem from time to time. The simple expedient of raising the chlorine dosage seems to relieve the situation.

During the past summer Barrie was troubled with taste in the vicinity of the open stand-pipe. It was found on emptying that a heavy algal growth existed which had an odor similar to the tastes. The reservoir was washed down, filled with a strong solution of copper sulphate, drained, and filled again. Activated carbon was thrown in from the top and allowed to stand for some hours. Shortly after this treatment the stand-pipe was covered over and since then they have had no trouble with taste.

Other municipalities in the province have used various methods for sudden appearances of taste, but have not found it necessary to arrive at a definite policy of treatment.

EVERY WATER A DIFFERENT PROBLEM

In conclusion, it should be emphasized that every plant has a different problem. That which will be found effective for one supply may not prove effective in another, though the tastes may seem to be identical. There are countless organic compounds resulting from decomposition which may cause taste, and for each one a different method of procedure may be found more satisfactory. F. E. Stuart (12) points out that the best method for control and purity in a supply would be to pre-chlorinate, use activated carbon in the coagu-

lating basin, post-chlorinate after filtration, and then ammoniate to prevent after growths throughout the system. This undoubtedly would guarantee positive taste control and ensure sterile water, but in most cases it should not be necessary to go to the expense this would involve. However, it stresses the point that it may be necessary to use more than one method to solve the problem completely. The work in this field has now become so advanced that the expert on taste feels confident that there is no problem concerning taste which cannot be solved.

(Presented before the Canadian Section meeting, April 5, 1934.)

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MANUFACTURE, USE AND CONTROL OF ACID AT TAMPA WATER PURIFICATION PLANT

By J. E. Lyles

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In March, 1926, the City of Tampa abandoned the wells and placed in operation its modern water purification plant designed by Mr. Nicholas S. Hill, Jr., consulting engineer of New York City.

The supply is obtained from the Hillsboro River which changes seasonally and at times very rapidly, according to the rainfall, from a soft, highly colored water to one which is only slightly colored and fairly hard. Various intermediate combinations of color and hardness are also obtained, so that at times we need only to decolorize and occasionally only to soften, but quite frequently we must both soften and decolorize. During the latter period it is at times more economical to soften before decolorization, but frequently the color must first be removed since this colloidal coloring matter prevents precipitation of calcium carbonate to such an extent that softening becomes impossible in the presence of color.

The plant is equipped with all modern machinery and auxiliary instruments to soften, decolorize, recarbonate, filter and sterilize with ammonia and chlorine.

Decolorization is effected by the combined use of alum and sulfurous acid, the manufacture, use and control of which will be discussed in this paper.

ACID PLANT

Considerable work has been done on the acid plant in order to make possible the efficient manufacture of acid in the quantities necessary and in order to synchronize the production of acid with the treatment of water. The acid plant as it now stands consists of:

1. A blower which supplies air for the controlled combination of sulphur. This blower is equipped with a home-made air meter by means of which the varying charges of sulphur are supplied with the proper amount of air.

2. A sulphur burner in which the sulphur is burned to form sulphur dioxide gas.

3. A cooling and settling tower in which the sulphur dioxide from the burner is cooled somewhat and suspended solids partly removed.

4. An absorption tower in which the sulphur dioxide is absorbed in water, thus producing sulphurous acid. In this tower, which is packed with coke, the gases flow upward and are absorbed in water which is introduced into the top of the tower and flows downward through the coke. The resulting acid is carried away through lead pipe and introduced either into the raw water or mixed with the alum solution. The line which supplies water to this town is equipped with an ordinary meter and with an orifice and mercury monometer. The purpose of this mercury monometer is to maintain a constant rate of water to the cooling tower. The rate of water flowing through this line will vary, due to variations of pressure.

Any variation, however, is immediately reflected on the monometer and can be controlled by means of a valve on the supply line. Too much water will cause the bottom of the tower to fill with acid and cut off the incoming gas, while too little water will result in poor absorption. The ordinary water meter on this line is used when running an efficiency test on the acid plant. The line that carries the acid away from the absorption tower is equipped with a gauge that shows the height of the acid that has collected in the bottom of the absorption tower.

The operator is given the dose of sulphur to be used in pounds of sulphur per hour per million gallons of water. The sulphur burner is then charged each hour with the indicated amount of sulphur. If the dose of sulphur has been set at one pound and we are receiving water at the filter plant at the rate of ten million gallons per 24 hours, the charge of sulphur placed in the sulphur burner would be ten pounds.

In order to control properly the production of acid, the charge of sulphur placed in the sulphur burner must be completely burned within the hour, but must not be burned up in less than an hour. Since the rate at which the sulphur burns depends primarily upon the amount of air supplied for combustion, it is very important that the air supply be controlled. This is done by setting the amount of air to be used in cubic feet of air per hour per pound per hour of sulphur; then whenever the charge of sulphur is changed, due either to a change in the dose of sulphur or a change in the amount of water

being received at the filter plant, the amount of air supplied to the burner is changed proportionally.

If the amount of water we are treating changes between charges, the amount of air being supplied to the burner is changed to correspond to the charge of sulphur that should be used for the changed rate of pumpage.

In order to assure even combustion, the burning sulphur is stirred once between charges through ports provided in the sulphur burner for this purpose.

Periodic efficiency tests are run on the acid plant. This is done by carefully measuring, over a period of four to six hours, the amount of sulphur burned and the amount and average strength of the acid produced. We find that we convert approximately 90 percent of our sulphur into acid.

After having modified our plant and having prescribed operating procedures that would assure, first, the efficient production of acid and, second, that our manufacturing process was synchronized with our low service pumpage, our next problem was that of working out a laboratory process that would tell us whether or not it paid us to use any acid, and if so—how much. The only excuse for using acid is, of course, that by its use the alum dose can be decreased and a net saving result.

LABORATORY CONTROL

The specific information that we had to have was:

1. How could we duplicate, in a gallon bottle in the laboratory, any dose of sulphur, in pounds of sulphur per million gallons per hour, in the plant?

2. How much alum must we save to pay for and show a profit on the use of any specific dose of sulphur?

Simple stoichiometric calculations tell us that one pound of sulphur per hour per million gallons of water at 90 percent efficiency is equivalent to 31 cc. of fiftieth normal sulphuric acid per gallon. This allows us to reproduce any dose of sulphur burned in the laboratory.

Knowing the cost of alum and the cost of sulphur, the amount of alum that must be saved to pay for any dose of sulphur can be calculated. However, further stoichiometric calculations show that if the alum is decreased and the sulphur increased in amounts that are equivalent in cost, more carbon dioxide will be formed from the

reaction of the alum, acid and calcium bicarbonate in the water than before; thus, an additional amount of alum, equivalent in cost to the extra line that must be used to reconvert this carbon dioxide to the bicarbonate, must be saved in order to break even on the increase sulphur dose.

For any specific cost of alum, sulphur and lime there is a specific amount of alum in grains per gallon that must be saved in order to pay both for the sulphur used, in pounds per million gallons per hour, and the extra lime used to convert carbon dioxide back to bicarbonate. This must be recalculated whenever the price of alum, lime or sulphur changes.

Being able now to translate from sulphur burned in the plant into its equivalent in cubic centimeters of acid per gallon in the laboratory and knowing how much alum must be saved to break even on any dose of sulphur, it is fairly simple to run a series of bottles in the laboratory and determine just what dose of sulphur is most economical. This is accomplished as follows:

First, a series of bottle tests are run, using various doses of alum, in order to determine how much alum alone is necessary to remove the color. The amount of alum required depends not only upon the amount of color present, but also upon the alkalinity. Having thus determined the lowest alum dose that can be used, and knowing how much alum must be saved in order to pay for any given dose of sulphur, it is an easy matter to run another series of bottles containing successively increasing doses of acid, and alum doses decreased sufficiently to show a profit, and observe the results obtained. The largest dose of sulphur that will work with its correspondingly decreased dose of alum is the most economical, and is the one used. For bottle tests we use gallon glass jugs. The water is stirred rapidly for several seconds and filtered after allowing to stand for 30 minutes.

You will note that no mention has been made of optimum pH; what we are interested in is the economic pH. In the use of acid a point of diminishing returns is soon reached, where the use of more acid, although it would allow us to further reduce the alum, would not save enough alum to pay for itself.

During 1927, 1928 and 1929 the cost of chemicals used was $12.67 per million gallons. During 1930 and 1932 we reduced the cost of chemicals used to $9.53 per million gallons, showing a saving of $3.14 per million gallons of water treated. In calculating these costs, the

same unit cost of chemicals was applied to both periods in order that the results might not be obscured by changing prices. Proper manufacture, use and control of acid was largely, although not wholly, responsible for this saving.

(Presented before the Florida Section meeting, April 11, 1933.)

CHEMICAL CONTROL AT THE FORT LAUDERDALE FILTER PLANT

By C. E. Fiveash

(Chemist Operator, Fort Lauderdale, Fla.)

The raw water is supplied from wells of 7-, 12- and 1-inch diameters. Six of these are on the Golf Course, one mile from the plant. Two are at the plant and are equipped with gas engines for emergency use.

Until the summer of 1930 all six of the wells on the Golf Course were used to pump water to the plant. Water used for sprinkling the Course was treated water. At this time we equipped one of the wells with a 115 foot head, 150 g.p.m. pump using the same motor ($7\frac{1}{2}$ H.P.) with a pressure tank system having an automatic pressure switch. This was quite a saving in the cost of water used in sprinkling.

The other five wells on the Course did not give us a uniform flow, making it necessary for the chemical feed machine to be changed to suit the flow of water.

Two of the wells had 400 g.p.m. 45 feet head, three with 400 g.p.m. 40 feet head with the water level from 8 feet to 12 feet below pump suction. The flow ranged from 497 to 573 g.p.m., but by changing the impellers, the high head to the low water level, we now have a uniform flow, or nearly so, 549 low, 554 g.p.m. high, making it unnecessary to change the chemical feed. The wells are run 24 hours and rotated.

The water from the wells is pumped through a 20-inch cast iron pipe to the plant, where it first passes over the aerators. From the aerators the water passes under the chemical machines in a cement flume 24 inches by 48 inches by 28 feet long to the mixing basins.

The chemical machines are in a line. Two dry feed lime, and 2 dry feed alum are 6 feet apart, or only 18 feet from the first lime to the last alum machine.

The mixing basins are in three units, each one designed to mix 2,000,000 gallons in 24 hours. These basins have slots in the walls so a board wall can be made to separate one from the other. Only two of these are in use, both working as one unit.

Before we began to experiment, this method was used: The lime and alum was added or dropped into the water as it passed under the machines, and then to the mixing basins where it was all mixed at one time, getting two hours and forty minutes of agitation. Then it went to the settling tanks.

Realizing that we were losing both lime and alum by this method, we decided to see if the treatment could be separated with better results.

First, we separated the two mixing chambers in order that the two could be mixed separately.

Second, in order to get the alum to the second mixing basin, or agitator, we placed a box under the alum machines with a lead pipe to the second mixing basin, using raw water from the aerators to dissolve and carry the alum out in solution, leaving the lime feed direct to the flow of water through the flume. In this way the lime goes to the first agitator receiving one hour and twenty minutes agitation. As the water passes to the second basin the alum is added in solution receiving one hour twenty minutes additional agitation.

We were using 12 to 14 grains of lime and 3½ to 4 grains of alum per gallon of water, with the results of a water of around 100 to 110 p.p.m. of hardness and 25 p.p.m. of free lime.

After the change in lime and alum feed the lime dosage was reduced to 10 grains per gallon and the alum to 3 grains per gallon with these results: The hardness was reduced to 70 to 80 p.p.m. with free lime at 8.5 p.p.m.

RED WATER ELIMINATION

We had been and were having a lot of red water trouble in the city mains, having to use about 2,000,000 gallons of water a month for flushing purposes. We did not believe that the change in the lime and alum treatment would help this trouble any; in fact, it made it worse, for the water had less lime as it went to the carbon dioxide basin. The result was a strong acid water after carbonation.

The pH value of the water before the chemical treatment change and after carbonation was 6.0, but after the chemical treatment change it dropped to 5.2.

The question was, could we reduce the strength of the carbon dioxide to raise the pH up to or above 7.0? This we tried with but very little success. About this time our superintendent, Mr. Chal-

fant, noted other cities were using ammonia to fight red water trouble, with good results. So we decided to see if it would help us.

In 1931 Mr. Chalfant bought an ammonia machine and with the help of Mr. Hoy it was installed. The ammonia chlorine treatment was tried. We soon found that we could not use this treatment with an acid water, and we could not get an alkali through the filter, as long as carbon dioxide was used, without the use of more lime, which would be nothing more than a waste of lime. We eliminated the use of carbon dioxide and got an alkali water and a pH of 8.2 before and an 8.0 after the chlorine treatment.

The best place to add the chlorine-ammonia treatment was where the water entered the clear water well (where the chlorine was added at this time). The water enters the clear well through a cement flume 24 inches by 48 inches at the bottom, and about the center of the well. It is carried to the south end through a 30-foot room, returning to the north end around a series of baffles 30 feet apart, from which point it is pumped to the city.

The clear well is 315 feet long, 135 feet wide and 12 feet deep. We put a wall of 2-inch by 12-inch cypress boards in this 30-foot room, making a 30-foot by 30-foot room leaving a 4-foot by 4-foot opening at the top.

The ammonia feed was placed in the mouth of the cement flume; the chlorine, in the opening in the wall. In this way the ammonia has about 2 hours in the water before the chlorine is added.

Within ten days' time after this treatment was started, our red water trouble began to improve and by midsummer (the time it was usually worse) it was almost cleared up.

We carry a residual of 0.1 p.p.m. of chloramine.

(*Presented before the Florida Section meeting, April 19, 1934.*)

COAGULANTS USED IN WATER PURIFICATION AND WHY

By L. L. Hedgepeth

(*Manager, Technical Service Department, Pennsylvania Salt Manufacturing Company, Philadelphia, Pa.*)

In the preparation of this paper the author has, in the interest of brevity, considered only those coagulants which are of economic interest to water purification plants in this section.

This discussion is, therefore, confined to sulphate of alumina, ammonia alum, sodium aluminate, copperas, chlorinated copperas, ferric sulphate and ferric chloride.

To answer properly the "why" of the title it is necessary that we consider the newer conception of the chemistry of coagulation in soft waters. Not so very long ago coagulation with alum was considered a mathematically definite reaction proceeding along one, or a combination of three reactions:

(Assuming the alkalinity as calcium)

$$Al_2(SO_4)_3 + 3Ca(HCO_3)_2 \rightarrow 3CaSO_4 + 2Al(OH_3) + 6CO_2$$
$$Al_2(SO_4)_3 + 3CaCO_3 \rightarrow 3CaSO_4 + 2Al(OH)_3 + 3CO_2$$
$$Al_2(SO_4)_3 + 3Ca(OH)_2 \rightarrow 3CaSO_4 + 2Al(OH)_3$$

With these fundamental equations as a starting point definite quantities of soda ash or lime were set down in tables as being the proper alkali doses for given conditions of natural alkalinity and alum doses.

Erratic flocculation, mud balls, short filter runs, heavy alum doses and sick floc all contributed their part during that period to the creation of a fertile field for application of colloid chemistry and pH control.

For soft or moderately alkaline waters it is now generally conceded that:

1. Coagulation is essentially a problem involving colloid chemistry.
2. It is best controlled by pH measurements.
3. The reaction does not proceed simply as indicated above, but is very complex, involving charge neutralization and anion removal.

To illustrate this we have reproduced three curves taken from

Lewis B. Miller's work in 1923 which are shown in figures 1, 2 and 3 following.

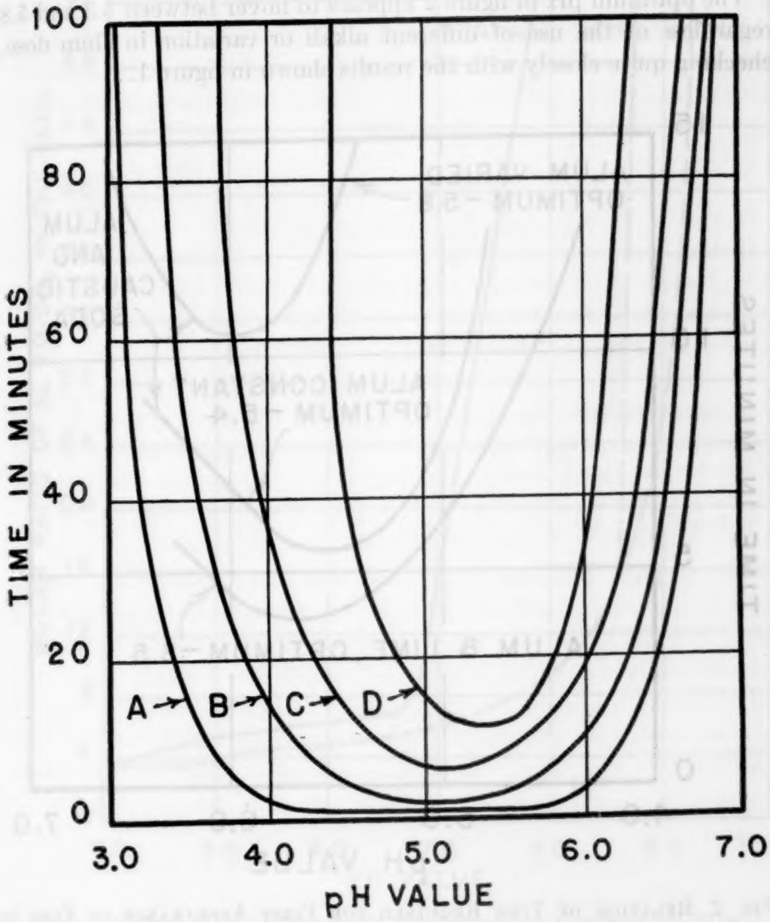

Fig. 1. Relation between Time Required for First Appearance of Floc in Solutions Buffered to Various pH Values with the Total Dissolved Mineral Matter Constant

A = 400 p.p.m. alum. *B* = 300 p.p.m. alum. *C* = 200 p.p.m. alum. *D* = 100 p.p.m. alum.

Figure 1 shows that even with abnormal doses of alum, ranging from 6 to 23 grains per gallon, the optimum pH remains approxi-

mately the same and coagulation is very poor in any dose on this particular water when the pH is appreciably off the optimum, even at neutrality—pH = 7.0.

The optimum pH in figure 2 appears to hover between 5.3 and 5.8 regardless of the use of different alkali or variation in alum dose, checking quite closely with the results shown in figure 1.

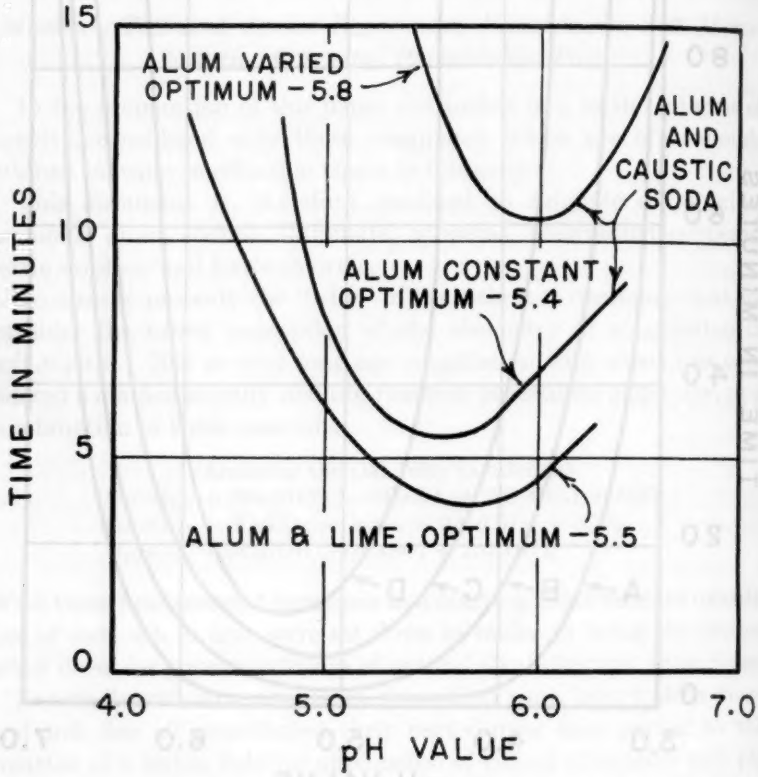

FIG. 2. RELATION OF TIME REQUIRED FOR FIRST APPEARANCE OF FLOC IN MIXTURES OF ALUM AND LIME AND IN MIXTURES OF ALUM AND CAUSTIC SODA

The writer recalls a peculiar instance at Southern Pines, N. C., on an extremely soft, slightly colored water where a broad optimum pH from 6.2 to 6.8, observed in jar tests using 1½ g.p.g. alum, separated into two definite narrow optimum points at 6.3 and 6.7 respectively with ¾ g.p.g. alum. Genter advises that he has observed

similar multiple optimum points on Baltimore digested sewage sludge liquor.

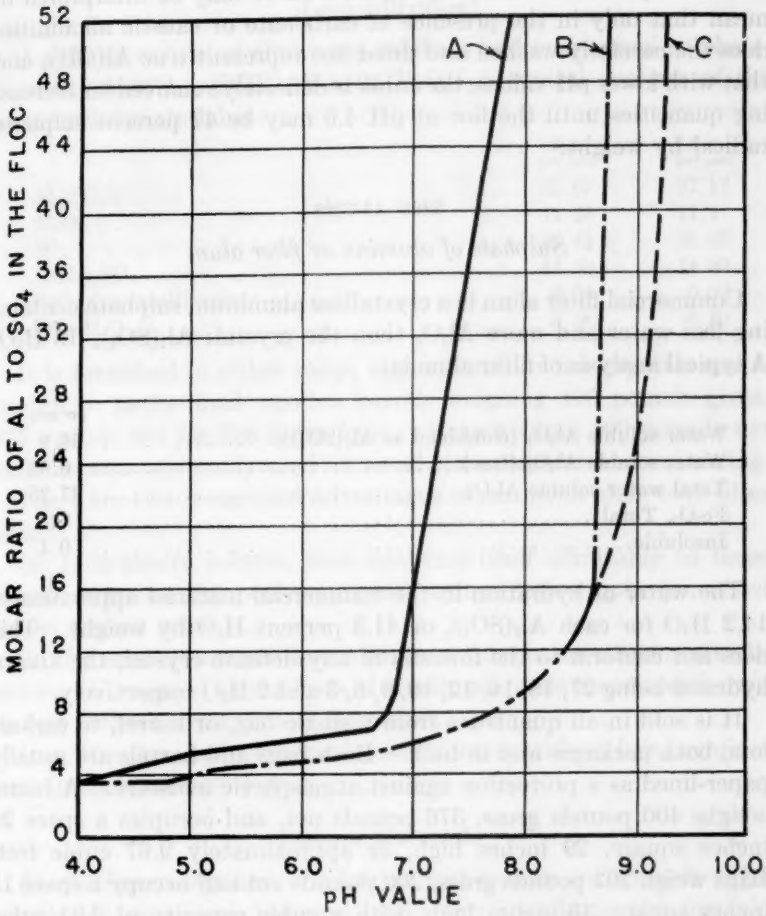

FIG. 3. RELATION BETWEEN pH AND SULPHATE CONTENT OF FLOC

A = 0.005 molar Al at 20°C. B = 0.02 molar Al at 20°C. C = 0.02 molar Al at 100°C.

Miller made another interesting contribution to the art of water purification when he showed that the alum floc in water plants was not aluminum hydroxide enmeshed with color and turbidity, but had a definite sulphate content varying from a mol $\frac{\text{Al}}{\text{SO}_4}$ ratio of 4 at pH

4.0–5.0 to a ratio of infinity or pure aluminum hydroxide at pH 8.6 to 9.4.

From a practical standpoint figure 3 curve may be interpreted to mean that only in the presence of carbonate or caustic alkalinities does the carefully washed and dried floc represent true $Al(OH)_3$ and that with lower pH values, the anion is definitely removed in increasing quantities until the floc at pH 4.0 may be 47 percent sulphate radical by weight.

THE ALUMS

Sulphate of alumina or filter alum

Commercial filter alum is a crystalline aluminum sulphate containing less water and more Al_2O_3 than the crystal: $Al_2(SO_4)_3 \cdot 18\ H_2O$. A typical analysis of filter alum is:

	per cent
Water soluble Al_2O_3 (combined as $Al_2(SO_4)_3$)	16.9
Water soluble Al_2O_3 (free)	0.35
Total water soluble Al_2O_3	17.25
Fe_2O_3, Total	0.4
Insoluble	0.1

The water of hydration in the commercial material approximates 14.2 H_2O for each $Al_2(SO_4)$, or 41.3 percent H_2O by weight. This does not conform to the formula of any definite crystal, the known hydrates being 27, 18, 16, 12, 10, 9, 6, 3 and 2 H_2O respectively.

It is sold in all quantities from a single bag, or barrel, to carload lots, both packages and in bulk. Both bags and barrels are usually paper-lined as a protection against atmospheric moisture. A barrel weighs 400 pounds gross, 376 pounds net, and occupies a space 24 inches square, 29 inches high, or approximately 9.67 cubic feet. Bags weigh 202 pounds gross, 200 pounds net and occupy a space 15 inches square, 30 inches high, with a cubic capacity of 3.91 cubic feet each.

It is by far the principal coagulant used in water purification, the yearly water works consumption being estimated at 120,000 tons. As indicated in figures 1, 2 and 3 its efficiency is dependent on the proper equilibrium being maintained, and used properly it will usually produce satisfactory clarification. Where the natural alkalinity is insufficient to permit the required alum dose at the optimum pH, additional alkali is necessary.

Lime is commonly used for this purpose, but in special cases such

as plants supplying textile or other soft water consuming customers, soda ash, sodium aluminate or caustic soda are used.

Ammonia alum

A definite crystal of aluminum sulphate and ammonium sulphate. Formula $Al_2(SO_4)_3 \cdot (NH_4)_2 SO_4 \cdot 24 H_2O$. A typical analysis of the commercial material is:

	Max. per cent	*Min. per cent*
$Al_2(SO_4)_3$	37.67	37.17
Al_2O_3	11.25	11.1
SO_3	26.42	26.07
$(NH_4)_2SO_4$	14.50	14.30
H_2O of crystallization	0.04	0.02
Free H_2O	0.56	0.10

It is furnished in either lump, egg, ground, or fine crystals and is packed in paper-lined wooden barrels weighing 400 pounds gross, 375 pounds net for the lump form. Kegs holding 100 pounds net each are also commonly used for small consumers such as swimming.

There are two recognized advantages of ammonia alum over filter alum:

(a) It is slowly soluble, thus adapting itself admirably to those plants or swimming pools equipped with solution pots connected across venturi tubes.

(b) Its ammonium radicle content is available for chlorine stabilization. Compared on the basis of aluminum oxide contained therein its cost is three times that of filter alum.

It is, therefore, not a commonly used water coagulant, being confined principally to swimming pools.

Sodium aluminate

An alkaline compound of alumina and caustic soda which in its completely pure and 1:1 mol. ratio corresponds to the formula $Na_2O:Al_2O_3$, often expressed as $Na_2Al_2O_4$ or $NaAlO_2$. However, in the interest of stability, the sodium aluminate manufacturers produce a product with excess caustic, being generally 1.2 Na_2O to 1 Al_2O_3.

A typical analysis of the best grade is:

	per cent
Al_2O_3	55.5
Combined Na_2O	34.04
NaOH excess	6.3
Na_2CO_3	4.5
Insoluble	0.4

Lower Al_2O_3 grades are available and also a stabilized aqueous solution which is particularly attractive for locomotive and boiler feed water use.

It is usually shipped in thin steel non-returnable drums of 108 and 425 gross pounds having a net weight of 100 and 400 pounds each. The small drum is 15½ inches diameter and 17½ inches high and the large drum 21 inches diameter and 34½ inches high. One hundred pound moistureproof burlap bags are also commonly used.

Sodium aluminate is used most effectively on those waters requiring an alkali with the alum. Contrary to the general impression extant in the water purification field its cost per unit of alumina and sodium oxide is not out of line with equivalent weights of these active ingredients in filter alum and soda ash or caustic soda.

In municipal water softening plants it has a potential field not yet realized because of the satisfaction and relatively low cost of lime—soda softening.

In some types of water treatment, such as internal boiler water softening it is the best combined coagulant and softening agent available.

Sodium aluminate has been found particularly efficacious as a secondary coagulant on those waters having an optimum pH in ranges where residual coagulant is likely to be excessive.

In figure 4 the beneficial effect of such secondary coagulation is graphically illustrated. This was taken from the 1928 results of Elizabeth City, N. C.

Figure 4 of a highly colored water illustrates the fact that, although coagulation is maintained at the optimum pH, the results may not be satisfactory. In this case one coagulation with any coagulant occurred only at pH values less than 5.0 and, therefore was unsatisfactory with respect to both color and residual alum as is indicated in figure 5.

By manipulating the treatment so that a second coagulation was obtained at higher pH values a filtrate satisfactorily free from color and alum was produced.

In such cases and with waters deficient in natural alkalinity, the alkaline coagulants have a definite place in effective water treatment.

It is interesting to note in figure 5 that in this particular water there is a definite relation between residual color and residual alum. To avoid later trouble it is essential that this type of water be given treatment before filtration which will reduce the residual coagulant.

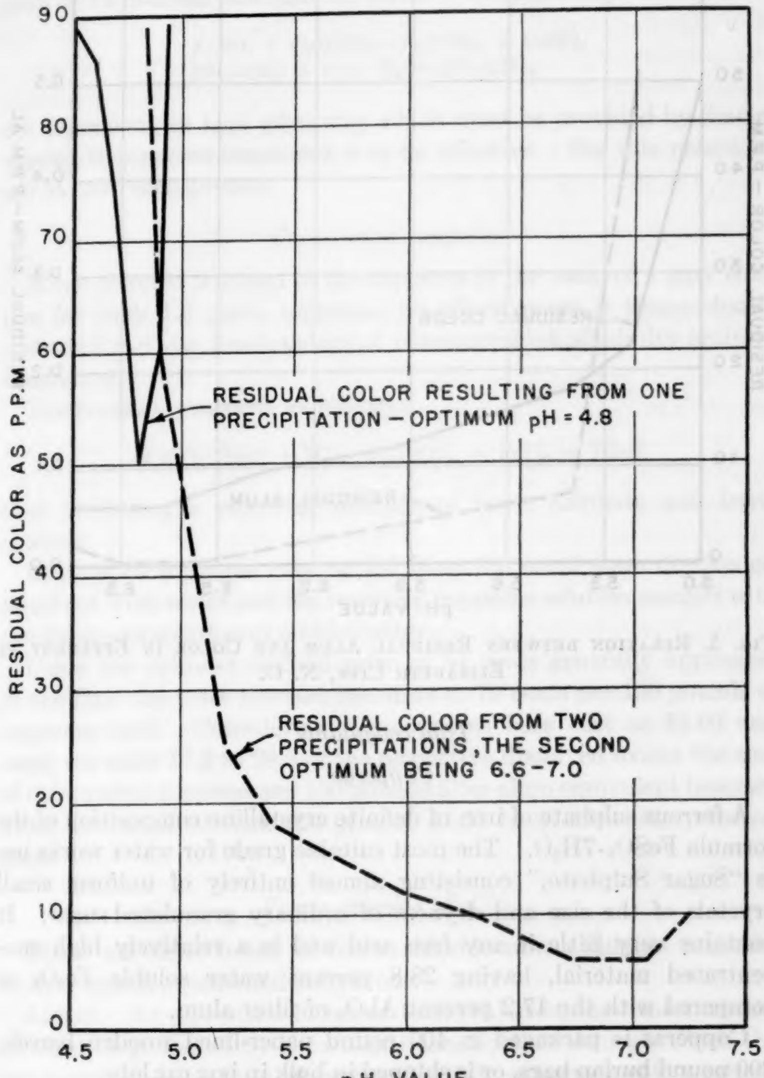

FIG. 4. COLOR—OPTIMUM pH RELATION

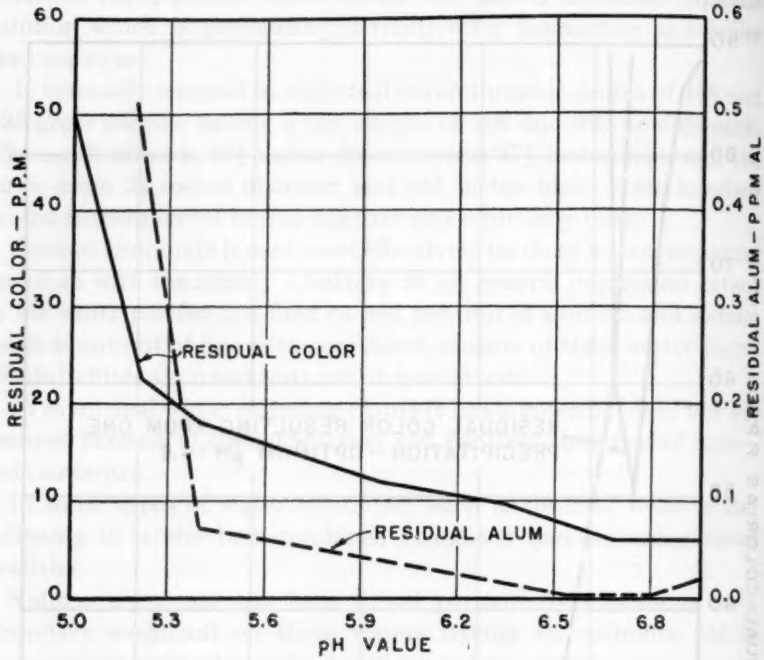

FIG. 5. RELATION BETWEEN RESIDUAL ALUM AND COLOR IN EFFLUENT AT ELIZABETH CITY, N. C.

Iron coagulants

Copperas

A ferrous sulphate of iron of definite crystalline composition of the formula $FeSO_4 \cdot 7H_2O$. The most suitable grade for water works use is "Sugar Sulphate," consisting almost entirely of uniform small crystals of the size and dryness of ordinary granulated sugar. It contains very little if any free acid and is a relatively high concentrated material, having 28.8 percent water soluble Fe_2O_3 as compared with the 17.2 percent Al_2O_3 of filter alum.

Copperas is packaged in 400 pound paper-lined wooden barrels, 200 pound burlap bags, or is shipped in bulk in box car lots.

It is attractive principally because of its lower active ingredient cost, being approximately one-half that of the equivalent water soluble oxide cost of alum.

However, effective precipitation is dependent on oxidation to its

ferric state with the dissolved oxygen of the water or with chlorine prior to its introduction into the water. The reactions—

$$FeSO_4 + Ca(OH)_2 \rightarrow Fe(OH)_2 + CaSO_4$$
$$2Fe(OH)_2 + O + H_2O \rightarrow 2Fe(OH)_3$$

are dependent on high alkalinity which must be provided by lime or caustic, if copperas treatment is to be effective. For this reason its use has not been general.

Chlorinated copperas

When chlorine is added to the copperas in the ratio of 1 part chlorine for each 7.8 parts copperas, its effectiveness is tremendously increased and the disadvantage of necessary high alkalinity entirely eliminated.

The reaction proceeds as follows:

$$6FeSO_4 \cdot 7H_2O + 3Cl_2 \rightarrow Fe_2(SO_4)_3 + FeCl_3 + 7H_2O$$

thus producing a powerful mixture of ferric sulphate and ferric chloride.

In practice copperas may be fed from the usual alum dry feeder, dissolved with water and the resulting copperas solution merged with the discharge solution of a chlorinator.

Using the cylinder carload price of 5½ cents generally applicable in the East the price increase amounts to 70 cents per 100 pounds of copperas used. Considering the copperas base cost as $1.00 and using the ratio 17.2 to 28.8 of the respective dissolved oxides the cost of chlorinated copperas per 100 pounds filter alum equivalent becomes $1.03 as compared with the present $1.25 to $1.35 works price on alum.

Ferric chloride ($FeCl_3$)

There are three forms of ferric chloride now available commercially—liquid, crystal and anhydrous.

Liquid. An aqueous solution of ferric chloride, the concentration of which is governed by the outside temperature through which the car moves, varying from 39 percent $FeCl_3$ in extremely cold weather, to 45 percent in extremely hot weather. The actual average concentration of shipments over a period of several years has been 42 percent.

Rubber-lined tank cars are used for shipment holding 8,000 gallons

each—representing an approximate average of 40,000 pounds anhydrous $FeCl_3$ per car. In special cases, 12-gallon carboys are used, but the freight costs in the carboy package makes this unsuitable for the low price ferric chloride market. This form, therefore, is suitable only for those plants which enjoy the following features:

(a) Railroad siding facilities.

(b) Storage tanks for one or more cars of ferric chloride.

(c) Freight rates, such that

$$\frac{\text{C/L rate Anhydrous Ferric Chloride}}{.96} \text{ minus } \frac{\text{Liquid Ferric Chloride tank car rate}}{.42}$$

is less than the base price difference of the two materials.

Crystals. The crystalline form of ferric chloride ($FeCl_3:6H_2O$) contains 60 percent ferric chloride by weight, remaining solid below 98.6°F. but melting at and above that temperature.

Hardwood barrels are used of 55 gallons capacity, containing approximately 435 pounds of lump material. This form is not particularly suitable for water plants on account of its slow solubility (20 hours solution time at room temperatures) and low melting point (98.6°F.).

Anhydrous. A water-free form of ferric chloride which is as near to 100 percent $FeCl_3$ as permitted by the impurities in the steel scrap from which it is made.

Non-returnable steel caustic soda type drums are used with friction top, holding approximately 100 pounds each. Its high melting point, 573.8°F., permits indefinite storage without deterioration or liquefaction. However, its extremely corrosive action on steel, in the presence of water, makes it necessary that the entire contents of a container be dissolved shortly after opening. This material is very deliquescent and will become gummy or soupy in a few hours time if left in an open container—particularly in humid climates.

Ferric chloride is a positive coagulant producing clean-cut flocculation in economical doses. On the basis of equivalent units of water soluble metallic hydroxides 1 pound of $FeCl_3$ = $2\frac{1}{2}$ pounds of filter alum. Thus the existing base price of \$1.25 to \$1.35 for alum creates a tremendous economy argument for ferric chloride which is now being sold in the middle west for approximately \$2.00 per 100 pounds of real $FeCl_3$ delivered as a liquor in tank car lots. This \$2.00 price is equivalent to 80 cents for alum. In Detroit the saving amounts conservatively to \$7.00 per ton of alum and even a city as remotely

located from ferric chloride producing points as Richmond can buy active ingredients at a lower price in ferric chloride than in filter alum, provided railroad siding facilities are available at the plant.

Prechlorination is essential with ferric chloride use in order to insure precipitation of all the iron.

Ferric sulphate

This is a new commodity now available from two manufacturers. It is a highly concentrated form of $Fe_2(SO_4)_3$ ranging from 62 percent $Fe_2(SO_4)_3$ to anhydrous. It is not as corrosive as ferric chloride and may be fed dry from suitable dry feeders.

It is shipped in wooden barrels and may be stored indefinitely without difficulty. It is a distinct addition to tools available for water purification.

CONCLUSION

Water coagulation is a complex problem which merits serious study of the fundamental changes in our scientific viewpoint on its behavior.

Six good coagulants are now commercially available in various forms.

The "why" of each coagulant involves questions of geographical location, base price comparisons, and chemical behavior of each particular water.

(*Presented before the Virginia Section meeting, July 13, 1934.*)

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EFFECT OF IRON IN THE DETERMINATION OF RESIDUAL CHLORINE

By R. D. Scott

(Chief Chemist, State Department of Health, Columbus, O.)

In the determination of residual chlorine with orthotolidine ferric iron has been regarded as not causing appreciable interference, unless present in relatively large amounts.

Kinnicutt in 1908, as noted by Monfort (1) concluded that about 7.0 p.p.m. ferric iron must be present to produce a color with orthotolidine. Ellms and Hauser (2) noted no color until 1.0 p.p.m. was present. Buswell and Boruff (3) observed no color other than the natural color of the solution with as much as 6.0 p.p.m. McCrumb (4) found that 10.0 p.p.m. of ferric iron gave a color no greater than that produced by 0.10 p.p.m. of residual chlorine.

After noting large false tests in waters almost free from nitrite and manganese and with total iron contents not exceeding 1.0 p.p.m., a study was made of the effect of ferric iron. It was observed that in distilled water quite small amounts, added as ferric sulphate gave false tests on prolonged standing with ortho-tolidine, using 1.0 cc. of the standard reagent to 100.0 cc. of sample (table 1).

To note comparative results with a natural water, Scioto River water was used; this had stood bottled for several months, the supernatant was then free from turbidity, iron and manganese and contained only 0.001 p.p.m. nitrite nitrogen. The color was recorded as 18.0 p.p.m., approximately equivalent to that of 0.01 p.p.m. chlorine with orthotolidine; this amount has been deducted in the tabulated data following.

On adding graded amounts of ferric sulphate solution it was found that false tests with ortho-tolidine developed at once and to a much greater extent than in distilled water, 0.1 p.p.m. ferric iron giving a significant false test (table 2).

With Columbus tap water and added iron, results intermediate between distilled and river waters were noted (table 3).

TABLE 1

FERRIC IRON	APPARENT CHLORINE, AFTER MINUTES NOTED		
	5	30	60
p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*
0.1	0	0.01	0.03
0.5	0.01	0.08	0.14
1.0	0.04	0.18	0.30

TABLE 2

FERRIC IRON	APPARENT CHLORINE, AFTER MINUTES NOTED	
	5	15
p.p.m.	*p.p.m.*	*p.p.m.*
0.1	0.05	0.04
0.5	0.20	0.20
1.0	0.40	0.35

TABLE 3

FERRIC IRON	APPARENT CHLORINE, AFTER MINUTES NOTED		
	5	30	60
p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*
0.1	0.025	0.05	0.06
0.5	0.08	0.17	0.20
1.0	0.12	0.25	0.30

TABLE 4

WATER TEMPERATURE	APPARENT CHLORINE, AFTER MINUTES NOTED		
	5	15	30
°C	*p.p.m.*	*p.p.m.*	*p.p.m.*
3	0	0.01	0.02
21	0.03	0.06	0.07
30	0.07	0.09	0.09

EFFECT OF TEMPERATURE

In the preceding runs, water temperatures were from 28° to 31°C. Temperature has considerable effect as shown by the following results, using the river water described to which was added 0.2 p.p.m. ferric iron (table 4).

EFFECT OF LIGHT

No differences in results were observed in parallel determinations carried on in diffuse daylight and in the dark.

It should be noted that these false tests are not due to the natural color of ferric solutions, since on the addition of as much acid as is contained in the standard ortho-tolidine reagent only rather large concentrations retain any color. Thus, while 10.0 p.p.m. ferric iron as ferric sulphate solution has a color intensity approximating that of 0.07 p.p.m. chlorine standard, on adding 1.0 cc. of 1 in 10 hydrochloric acid to 100.0 cc. the color disappeared in about 8 minutes.

It was found that false tests due to ferric iron were much less with the use of a modified ortho-tolidine reagent, similar to that previously described by the writer (5) using for 100.0 cc. of sample 2.0 cc. of:

	cc.
Standard ortho-tolidine solution	50
Distilled water	35
Concentrated hydrochloric acid	15

TABLE 5

FERRIC IRON	APPARENT CHLORINE, AFTER MINUTES NOTED (MODIFIED O.T. REAGENT)		
	5	15	30
p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*
0.1	0	0.01	0.01
0.5	0.01	0.05	0.07
1.0	0.02	0.08	0.10

2.0 cc. of this reagent contains 4 times the amount of acid present in 1.0 cc. of the standard reagent. The results shown in table 5 were observed on adding iron to the river water mentioned.

It is seen that with 0.5 p.p.m. ferric iron present, the apparent chlorine after 5 minutes is 0.01 p.p.m. as compared with 0.20 p.p.m. using the standard reagent. This modified reagent has also been found of advantage in lessening nitrite false tests and in hastening the color development with residual chlorine. It does not lessen false tests from manganese which, however, may be removed as described in the preceding paper (5).

DETERMINATION OF FERRIC IRON

To 100.0 cc. of the water add 0.8 cc. of 1:1 HCl solution and 1.0 cc. of KCNS solution (20.0 grams in 100.0 cc.). Compare the color

developing with that of standard ferric iron solutions, similarly treated.

FERRIC IRON AND STARCH-IODIDE

While in acid solution ferric iron produces strong color with starch-iodide, no color whatever develops in ordinary waters if no acid is added. It was found that no blue tint appeared with ferric iron unless the water was made more acid than about pH 3.9. Accordingly, the starch-iodide test of the preceding paper (5) should be applied as a confirmatory test for residual chlorine, unless it has been ascertained that no appreciable amounts of iron, manganese or nitrite are present.

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SOME DEVELOPMENTS IN SANITARY ENGINEERING LABORATORY EQUIPMENT AT NEW YORK UNIVERSITY

By Thomas M. Riddick

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It is indeed fortunate for sanitary engineers that there has been available for the past twenty-five years a "Standard Methods" for the various chemical, biological and physical tests applied to the examination of water and sewage. Notwithstanding the fact that these editions have undergone changes and revisions with the increase of knowledge in the several sanitary sciences, they have at all times presented a complete, concise and reasonably accurate procedure. A uniformity of procedure, however, is quite difficult in many tests unless a uniformity of apparatus exists, and differences of either may result in data which is not truly comparable. With the latter phase this paper chiefly concerns.

Sanitary chemistry, bio-chemistry, biology and bacteriology are not new and distinct sciences. They are rather a specialization of these particular branches with regard to the constituents found in natural or spent natural waters. It is generally agreed that the primary constructive specialization in this field began in this country with the Lowell Experiment Station of the Massachusetts State Board of Health about 1890, but since that time there are few sections of the country which have not and which are not today contributing towards its advancement.

In the use of engineering data we are prone to accept printed values regardless of the conditions under which these data were collected. For computations of runoff from land surfaces we may consult any standard handbook and find coefficients which vary from 50 to 200 percent of the mean value of all such coefficients. In sanitary biology we find volumes by Whipple, or Whipple and Ward, but upon selecting a sample of water from our southern streams, we may find that few if any of the microörganisms present have been previously

identified or described. Extreme care must therefore be used to determine first whether or not the conditions under which data were collected are comparable with those of the problem at hand.

Before applying data on the floc formation of coagulants we must consider the procedure and technique of the analyst in performing such experiments. Few reports give such information and from our general knowledge of laboratory technique we may surmise that some analysts used battery jars with manual stirring, while others may have used mechanical stirring with beakers as containers. Results obtained under these varying conditions cannot therefore be compared, and it is obvious that uniformity of equipment is as essential as uniformity of procedure.

In all branches of science and industry we find that practice is always ahead of theory. Considering the activated sludge process, we find that practice dates back to 1912, whereas theory is still being formulated. Just so in laboratory analyses we find procedure, technique and theory being developed prior to the building of the most suitable apparatus for making these determinations. There are several items of laboratory equipment peculiar to the analyses of water and sewage, such as the Imhoff Cone, the Sedgwick-Rafter Funnel, the Whipple Eyepiece, etc., but in the majority of cases such equipment has been utilized without regard for its suitability, from that employed by chemists, biologists and bacteriologists.

With the desire in mind to improve and specialize sanitary laboratory apparatus, and with due regard for simplification and facilitation of procedure as well as reduction of cost, the writer has developed certain new devices and improvements of existing apparatus in connection with outfitting the Sanitary Engineering Laboratory at New York University. Some of this equipment is described herein with the hope that it may prove helpful to laboratory workers and may elicit discussion as to standardization of such apparatus.

20°C. INCUBATOR

The technique, procedure and logic of the Bio-Chemical Oxygen Demand determination has been well worked out by Theriault and Phelps, and all relative information up to the time of publication is presented in several U. S. Public Health Service publications, namely, Bulletin 173, Supplement 90 and Reprint 1475 from Public Health Reports. In general, B.O.D.'s refer to incubation at 20°C. for a five

day duration of time, but with our present knowledge of this subject it is comparatively easy to compute the five-day 20° value from data obtained by incubation at temperatures other than 20°C. or periods of incubation greater or less than five days.

In reviewing data from various plants and research organizations it is surprising to note the great variation in incubation procedure. In many instances, a room of "fairly constant" temperature, or a tank located in such a room, has been used, with average values approximated from readings which may vary as much as 5°C. from the mean temperature. Although a water seal for sample bottles has been recommended by Theriault and others, we find in practice that many incubations are made without this protective device. It is possible that results obtained under varying temperatures with or without the use of water seals may approximate values obtained under carefully controlled conditions, but such occurrences are more or less accidental. If no means of controlling the temperature is available such results are perhaps better than none at all, but data of this type is valuable only in a relative sense to the plant at which it was collected. This procedure gives no surety of being able to duplicate results either at the laboratory in question, or elsewhere.

There are several 20°C. incubators on the market which are designed for or may be adapted to the B.O.D. determination. However, in many types the following disadvantages are noted:

1. Lack of tanks for providing water seals.
2. High initial cost per unit capacity.
3. Small capacities for continuous B.O.D. determination.
4. High operating cost due to refrigeration or icing, as well as the inconvenience of the latter.
5. Lack of facility in placing or extracting samples when water tanks are provided.

The incubator shown in figure 1 is solidly constructed of sheet metal, with the conventional asbestos air cell lining. The usual ice chamber or refrigeration unit has been omitted and an additional tank has been substituted. There are four coils or circuits of copper tubing extending around the bottom, top and sides of the incubator. A connection is made from the manifold supplying these coils with cooling water, to the cold water line. It has been found that New York City water even during the hottest months of the year is always below 20°C., therefore, by circulating tap water at a low rate of flow the cooling elements are always below this critical temperature. The

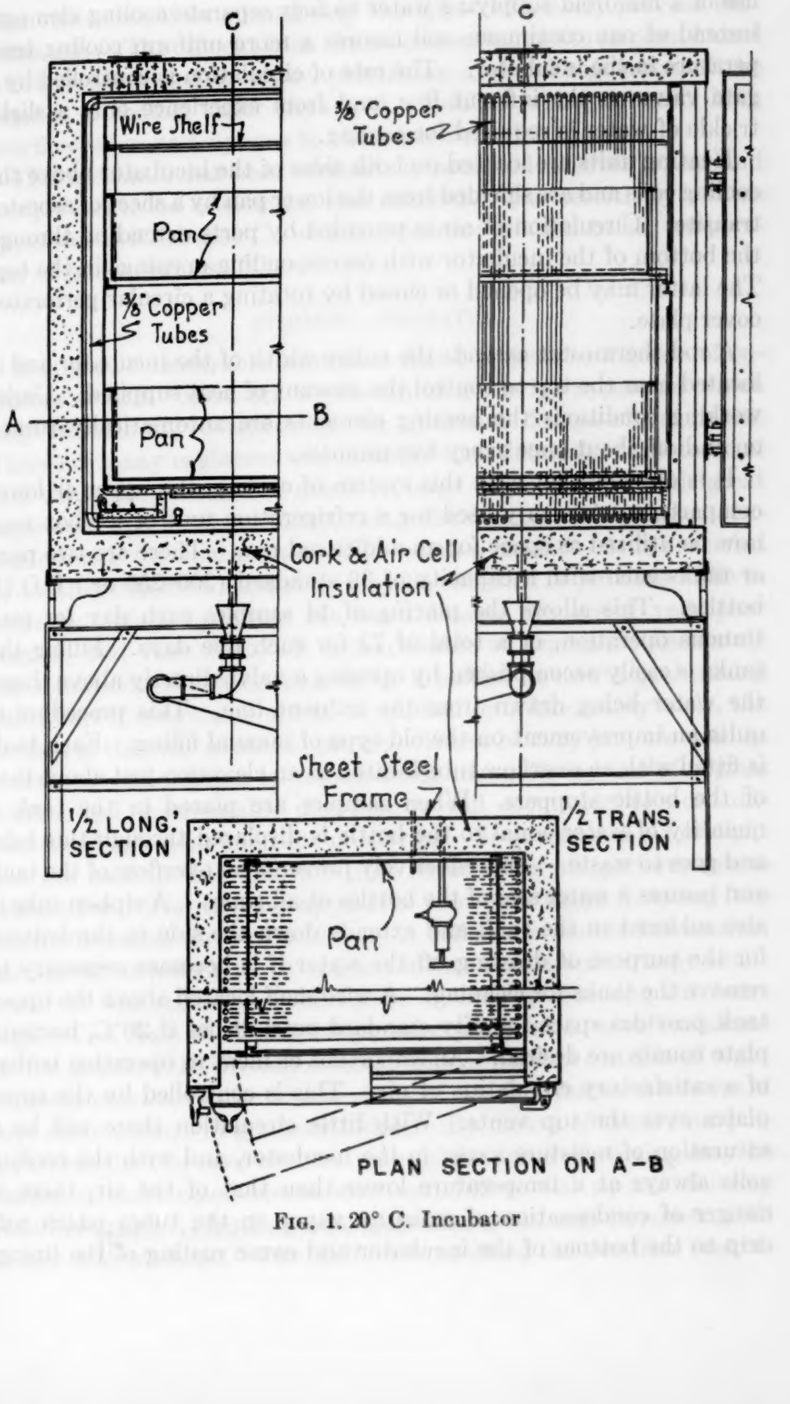

FIG. 1. 20° C. Incubator

use of a manifold supplying water to four separate cooling elements instead of one continuous coil insures a more uniform cooling temperature in the incubator. The rate of circulation is controlled by a gate valve on the influent line, and from experience only a slight trickle of water is required for cooling.

Heating units are located on both sides of the incubator above the cooling coils and are shielded from the lower pan by a sheet of asbestos transite. Circulation of air is provided by ports extending through the bottom of the incubator with corresponding openings in the top. The latter may be opened or closed by rotating a circular perforated cover plate.

A rod thermostat extends the entire width of the incubator and is located near the top to control the amount of heat supplied. Under working conditions the heating elements are automatically turned on and off about once every five minutes.

It is obvious that with this system of cooling, the upper or lower compartment formerly used for a refrigeration unit or ice box may now be utilized as space for an additional pan. There are two pans or tanks each with a capacity of 36 standard (200–250 cc.) B.O.D. bottles. This allows the placing of 14 samples each day for continuous operation, or a total of 72 for each five days. Filling the tanks is easily accomplished by opening a valve directly above them, the water being drawn from the influent line. This procedure is quite an improvement on the old type of manual filling. Each tank is fitted with an overflow tube located at an elevation just above that of the bottle stoppers. When samples are placed in the tank a quantity of water equal to the bottle is displaced through this tube and goes to waste. This effectively prevents an overflow of the tank and insures a water seal of the bottles at all times. A siphon tube is also soldered to the tank and extends down the side to the bottom for the purpose of drawing off the water if it becomes necessary to remove the tanks for cleaning. A wire shelf located above the upper tank provides space for fifty standard petri dishes if 20°C. bacteria plate counts are desired. An important element in operation is that of a satisfactory circulation of air. This is controlled by the cover plates over the top vents. With little circulation there will be a saturation of moisture vapor in the incubator, and with the cooling coils always at a temperature lower than that of the air, there is danger of condensation of moisture vapor on the tubes which will drip to the bottom of the incubator and cause rusting of the lining.

The vents should be opened only enough to effectively prevent condensation. The effluent from the cooling coils flows to an open funnel which is connected to sewer, permitting a visual regulation of the amount of cooling water circulated. Rubber tubing connects both overflow tubes and siphons to the waste funnel.

This incubator has been successfully operated for over a year and has proved to be economical and efficient. The sensitivity of this apparatus is 0.1 degree C., with maximum variation in air temperature of plus or minus 1°C.

STIRRING APPARATUS

It is with considerable hesitation that I present to a group of engineers or plant operators the design of a stirring apparatus which may be used for determining the optimum dosage of coagulant. There are many engineers who consider such determinations to be of real value, but there also exists as large a group, who with great experience and good authority, bring the discussion to a hasty conclusion with the final phrase, "Not worth a damn." It is conceded by all that excellent floculation may be obtained in jar tests while in coincident plant operation the same dosages are giving very poor results—and vice versa. It is impossible to reproduce accurately the conditions of mixing effected by a baffled or mechanical mixing basin, but if coagulants are to be studied on a laboratory scale, the jar test is the only available means. When battery jars are used as containers and stirring is accomplished manually by use of a glass stirring rod, considerable discrepancy will occur due to non uniformity of agitation and time of stirring. If as many as six or eight jars are used in this test, the time required for its performance is prohibitive. The stirring apparatus shown in figure 2, to say the least, eliminates these difficulties. A ceiling fan motor was used on account of its low r.p.m. as well as the fact that it was already available. It was mounted upside down by simply reversing the bearings. Two sizes of drive pulleys were provided to give variations in the speed of the driving motor. The apparatus consists of eight separate stirrers, on the first shafting of which is fastened a series of four drive pulleys of graduated sizes. By means of these four pulleys, plus the two sizes of drive pulleys, the speed of stirring may be varied in eight equal increments from 100 to 400 r.p.m. Stirring rods were made by bending solid glass tubing and may be constructed to any desired shape. The shelf for supporting the two liter beakers

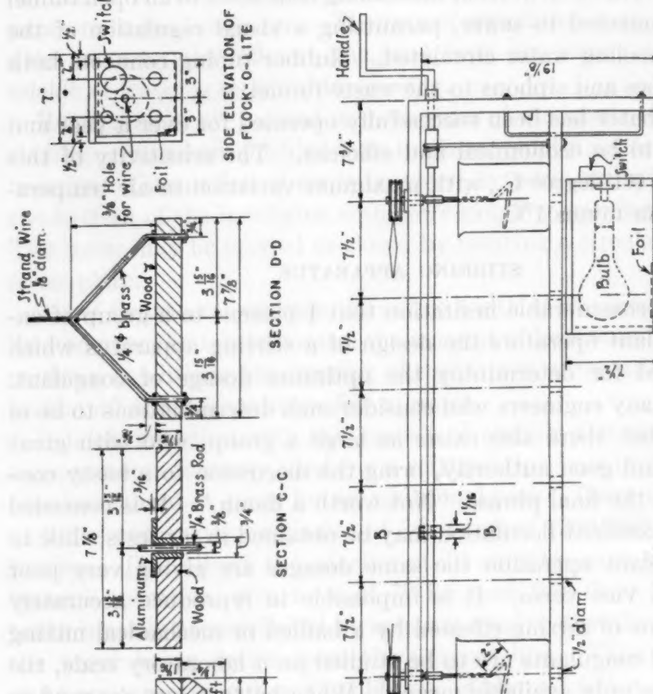

FIG. 2. STIRRING APPARATUS

has concentric circles etched in the wood with each center directly under a stirrer. This facilitates the accurate placement of any size of beaker. The shelf may be easily raised or lowered by means of a crank so that beakers may be put in place without removing the stirring rods. Upon raising, the shelf is held in place by a ratchet and pawl. It has been found that the lower speeds are better for floc formations since there is no tendency to break down the particles once formed into a fine pin floc.

A half inch hole is bored through the shelf in the center of each concentric circle. Underneath it is placed the Floc-A-Lite shown in figure 2. This consists of a 200 watt bulb mounted in an asbestos lined box with a circular opening on top for projecting a beam of light upwards. For determining the relative density and size of floc formed, the light is successively placed underneath each beaker. Floc particles stand out boldly and the effect is similar to that of the Tyndall Cone.

In summarizing the advantages, it may be said that the Jar test may be of value, and especially so where alkalinity must be added to effect floculation. The apparatus described gives absolute uniformity of mixing to each of the eight samples, and the adjustable speeds permit a ready change from rapid to slow agitation in order to more nearly simulate plant operating conditions. The ease of placing or extracting beakers due to the movable shelf reduces the time required for this procedure to such an extent that the jar test may be made a matter of daily routine.

EVAPORATION HOOD FOR STEAM BATH

The procedure for the determination of solids has not been given in as much detail in "Standard Methods" as have many other tests. Good technique, however, requires evaporation to dryness over a steam bath, drying at 103°C., desiccation, burning at a uniform "cherry red" temperature in the muffle furnace, moistening to restore waters of crystallization, further drying, desiccation, etc.

In working with freshly settled or precipitated sewage sludges, however, evaporation to dryness over a steam bath requires four or five hours, during which we are confronted with what Falstaff calls "the damnedest stench that e'er offended man's nostrils." The conventional type of fume hood is inadequate unless a blower of considerable capacity is used, and even then fumes of raw sewage are likely to permeate the atmosphere.

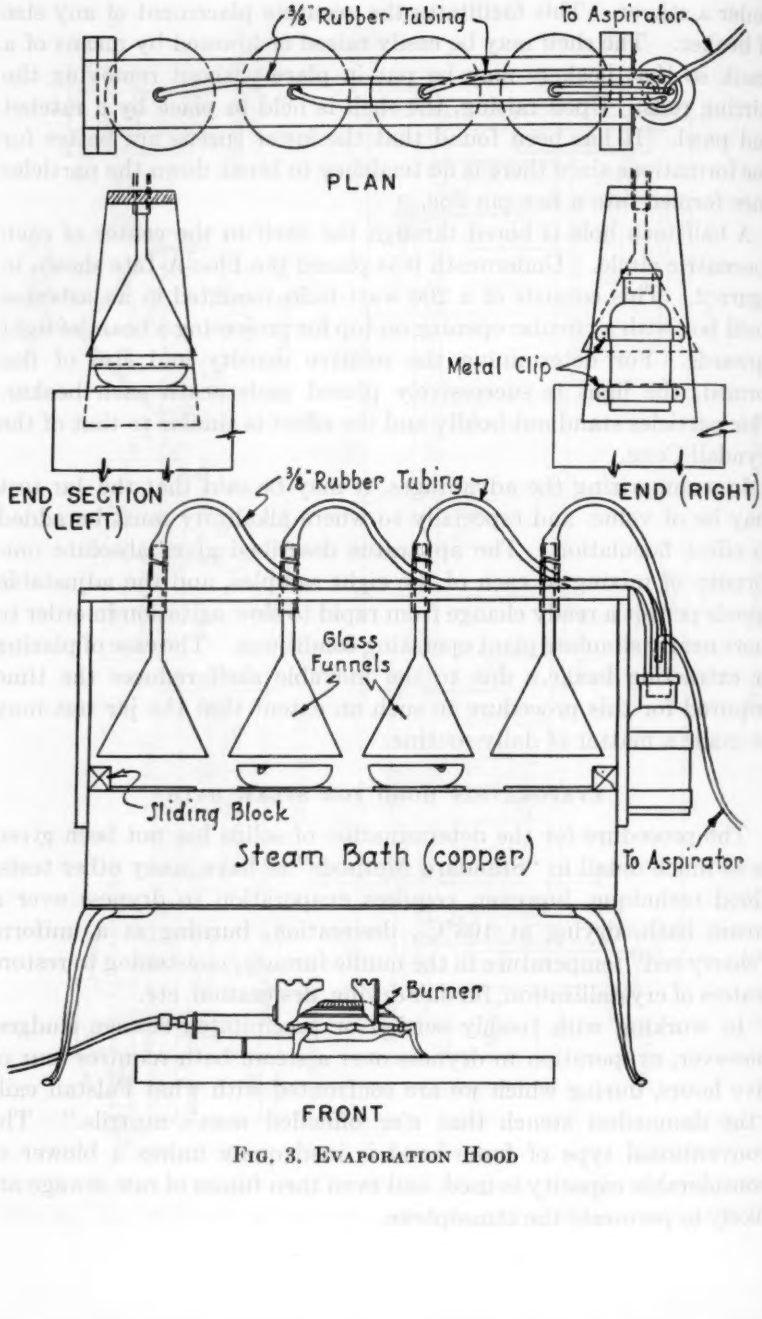

FIG. 3. EVAPORATION HOOD

Since it was necessary to have an entire absence of any odors, the set-up shown in figure 3 was adopted. The steam bath is of the usual type and has a direct connection to the hot water line so as to reduce the time required to bring the bath to boiling temperature. The evaporation hood consists of a wooden frame which is mounted on top of the bath and is held in place merely by its weight. To the frame are attached inverted funnels which fit snugly around each evaporation dish. A rubber tubing connects each funnel to a wide-mouth reagent bottle serving as a manifold. Another tube connects the manifold to an aspirator through which water is continuously forced.

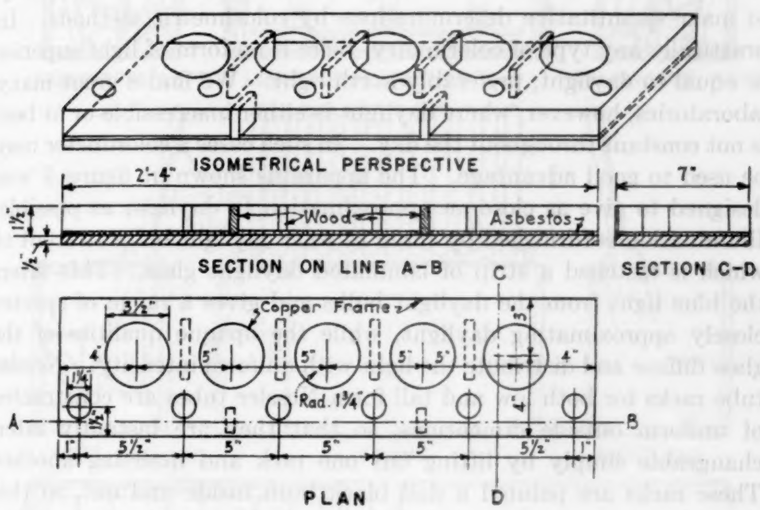

FIG. 4. DISH AND CRUCIBLE TRAY

It has been found that the suction created is sufficient to draw off all malodorous fumes arising from sewage, while the reduction of the moisture vapor on the surface of the liquid tends to considerably lessen the time required for evaporation.

DISH AND CRUCIBLE TRAY

Whenever there is the necessity of determining the solids content of several different samples, there is entailed a considerable labor in transporting dishes and crucibles to and from the desiccator, balance, muffle furnace and drying oven. In order to eliminate the useless

carrying of each individual sample, as well as to provide a receptacle for the hot dishes as they come from the muffle furnace, the tray shown in figure 4 was constructed. A strip of sheet copper provides support for the dishes and crucibles, and is attached to a wooden frame covered with asbestos. This precaution is necessary since dishes taken directly from the muffle furnace are at a temperature of about 600°C. Each opening in the tray is numbered, hence there is little probability of confusing one dish for another during handling.

COLORIMETER

Since iron, manganese, phenol, color, chlorine, etc., exist in natural or treated waters in such minute proportions, it becomes necessary to make quantitative determinations by colorimetric methods. In practically any type of colorimetry, there is no form of light superior or equal to daylight, preferably north light. We find a great many laboratories, however, where daylight is either inaccessible or at best is not constant throughout the day. In such cases a colorimeter may be used to good advantage. The apparatus shown in figure 5 was designed to give as close an approximation to daylight as possible. Illumination is furnished by three 25 watt daylight bulbs in front of which is fastened a strip of laminated daylight glass. This filters the blue light from the daylight bulbs and gives a range of spectra closely approximating daylight, while the opaque qualities of the glass diffuse and distribute the light with uniform intensity. Nessler tube racks for both low and tall form Nessler tubes are constructed of uniform outside dimensions, so that they are instantly interchangeable simply by lifting out one rack and inserting another. These racks are painted a dull black both inside and out, so that the observer views the color of the standard throughout the entire length of the Nessler tube without the possibility of light filtering in from the sides.

This colorimeter gives good differentiation between adjacent standards, and its facility lies in the ability to have on hand permanent standards for the several mentioned tests which are instantly interchangeable.

CONSTANT TEMPERATURE TANK

A constant temperature tank has various uses in any analytical or research laboratory. The one pictured in figure 6 has been used as a 20°C. incubator for B.O.D. samples as well as a water bath for the

maintenance of uniform temperature of digesting sludges. The tank is heated by two circuits of coiled nichrome resistance wire, strung through submerged pyrex glass tubing located at the bottom

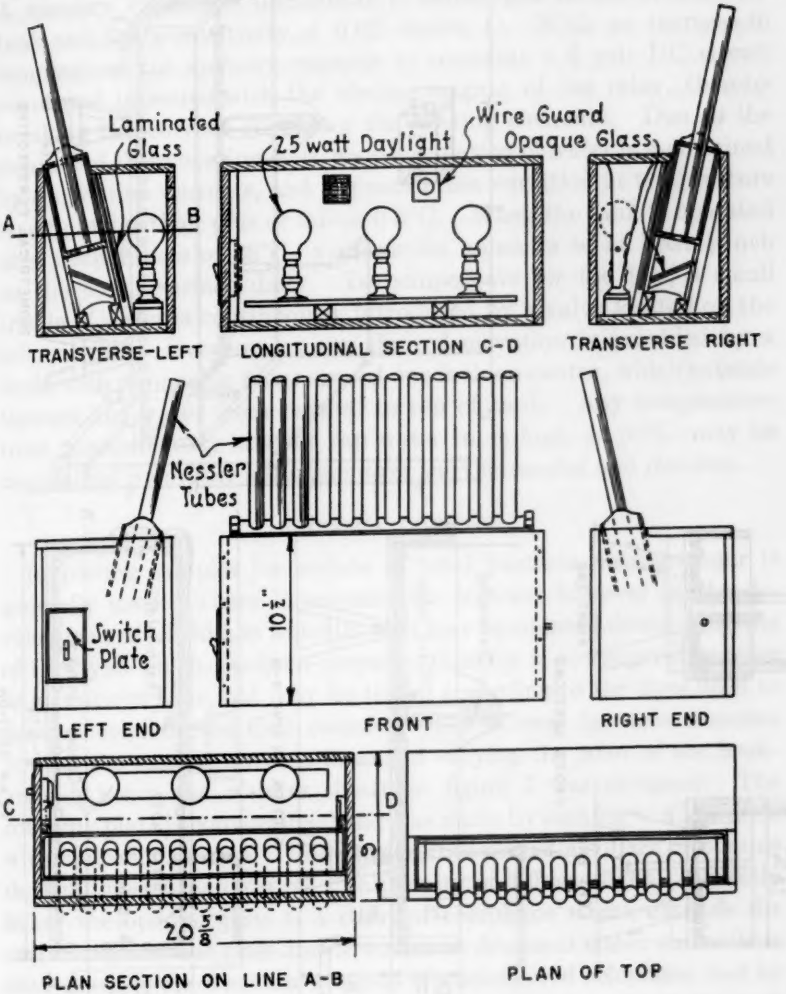

FIG. 5. COLORIMETER

and around the inner sides of the tank. The length of wire in each heating element was determined empirically, and is sufficient to raise the temperature of the wire to 150°C. Both heating elements operate

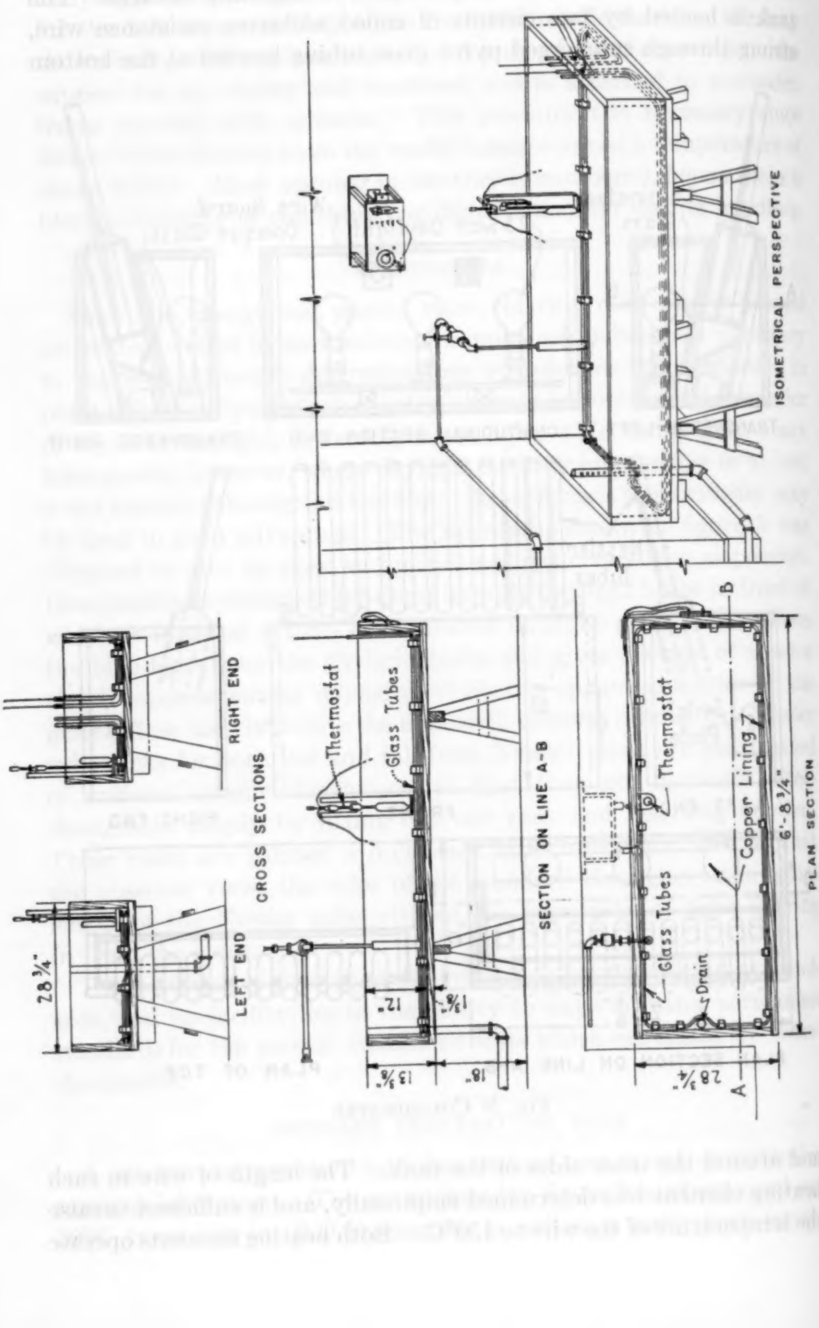

Fig. 6. Constant Temperature Tank

on standard city alternating current, and are placed in series with a rheostat, permitting a decrease of heat from 150°C. to any desired temperature. The circuit is closed or broken by means of a relay. A mercury expansion thermostat is submerged in one side of the tank and has a sensitivity of 0.02 degree C. With an increase in temperature the mercury expands to complete a 6 volt DC circuit connected in series with the electro magnet of the relay, thereby breaking the current supplying the heating elements. Due to the location of these heating coils, good circulation of water is maintained by convention currents, and the maximum variation in temperature is not greater than plus or minus 0.5°C. When the tank is operated at a temperature of 28°C., evaporation amounts to at least $\frac{1}{8}$-inch on the water surface daily. To compensate for the loss, a small trickle of water is continuously introduced by a valve located on the influent line. Overflow at any desired elevation is provided by a drain with removable plugs spaced one inch on center, which extends through the water from bottom to top of tank. Any temperature from approximately that of tap water to as high as 30°C. may be maintained by proper adjustments of the thermostat and rheostat.

BACTERIA COUNTER

In plating samples for counts of total bacteria nutrient agar is generally used. There is considerable interest however in the development of a media in which B. Coli may be counted direct. Media of this type which has been prepared thus far is not neutral in color as is nutrient agar, but may be tinted according to the dyes used to develop color in the Coli colonies. The several bacteria counters now on the market have no means of varying the color of the background, hence the counter shown in figure 7 was designed. The counting plate is conventional and was made by etching window glass with hydrofluoric acid. Underneath it is placed a square of opaque daylight glass which insures a uniformity of diffused light. Directly below the opaque glass is a sheet of celophane which extends the entire length of the glass and is wound on drums at either end. This sheet is made up of several sections of vari-colored celophane and by revolving the drum a particular color may be shown. A 60 watt blue glass bulb is mounted in a Dim-o-Lite socket, which can be adjusted so as to give optimum lighting to any petri plate. This apparatus has given efficient service and although the changeable background of color offers no distinct advantage using nutrient agar, it may prove of value later if colored media is used.

TITRATION OR MICROSCOPE LIGHT

The light shown in figure 8 needs no explanation. It consists of a 60 watt blue glass bulb in front of which is mounted a square of laminated daylight glass. This device is found very convenient and serves as a background for the Walpole comparator block in making pH determinations, as a titration light for noting indicator changes and as a general microscope lamp.

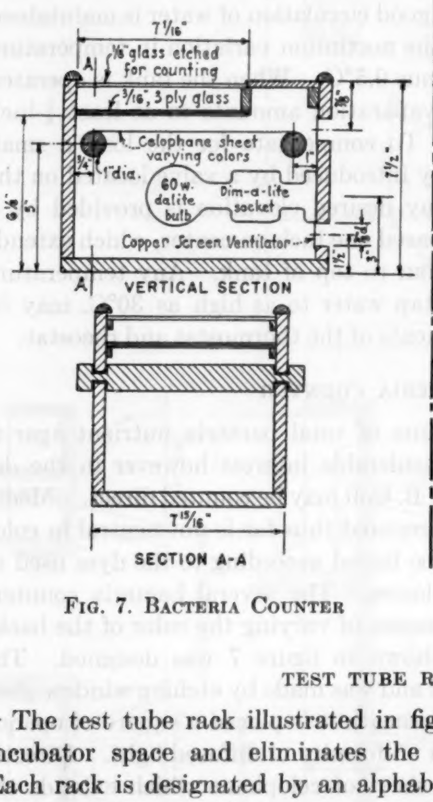

FIG. 7. BACTERIA COUNTER

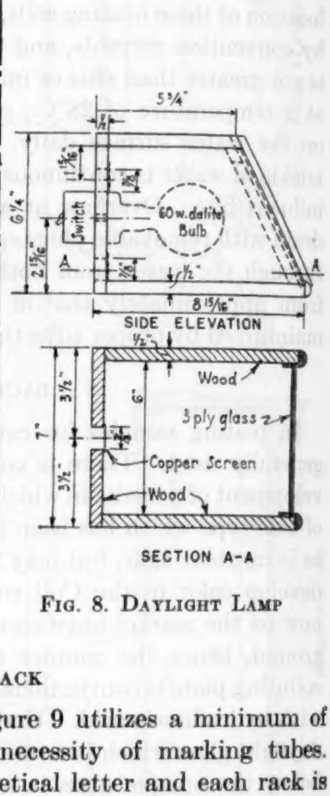

FIG. 8. DAYLIGHT LAMP

TEST TUBE RACK

The test tube rack illustrated in figure 9 utilizes a minimum of incubator space and eliminates the necessity of marking tubes. Each rack is designated by an alphabetical letter and each rack is numbered successively from one to eleven. Dilutions are marked 1, 0.1, 0.01 etc. so that any samples may be accurately identified B—3—1:100 etc. The drilled holes are slightly larger in diameter than the test tubes, permitting good circulation of air throughout the incubator. The bottom of the rack is covered with no. 4 mesh wire for like purpose. It is noted that the holes for 10 ml. portions are larger than those for 1, 1:10, 1:100 etc. dilutions. By using larger

test tubes for the double strength (23.6 g.p.l.) broth there is eliminated the possibility of confusing it with those of single strength.

The equipment described in this paper represents the results of attempts to improve on existing apparatus for the special needs of the new Sanitary Engineering Laboratory at New York University. It is designed to fit into this particular laboratory, in relation to the

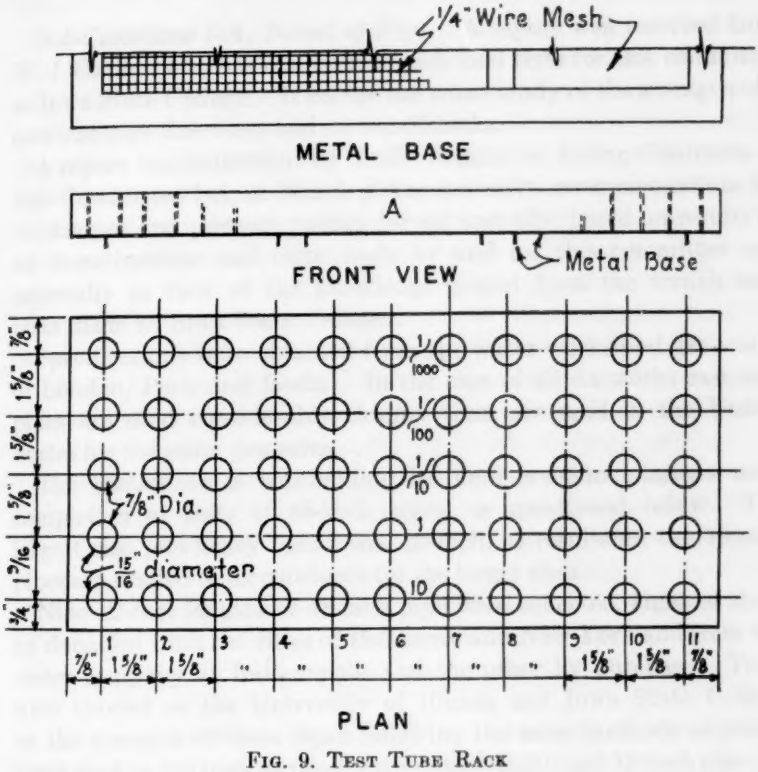

FIG. 9. TEST TUBE RACK

many other pieces of equipment of more or less conventional types. Throughout the design of the laboratory its dual purpose had to be kept in mind: i.e., (a) routine laboratory instruction and (b) research. The entire laboratory has been so designed and equipped that virtually any standard test or special laboratory investigation likely to arise in sanitary engineering practice can be performed. The writer is largely responsible for the design of the apparatus described

herein and is in charge of the laboratory which functions in the Department of Sanitary Engineering under the direction of Professor Thorndike Saville. The Department of Sanitary Engineering is part of the College of Engineering of which Professor Collins P. Bliss is Dean.

(*Presented before the 4-States Section meeting, March 8, 1934.*)

REPORT OF A-21, SECTIONAL COMMITTEE ON SPECIFICATIONS FOR CAST IRON PIPE AND SPECIAL CASTINGS, YEAR 1933

TECHNICAL COMMITTEE 1—DIMENSIONS

Sub-Committee 1-A, Barrel of Pipe. A report was received from W. J. Schlick who has made the trench load tests for this committee at Iowa State College. It covers the latest study of the strength of a cast iron pipe line when laid on wood blocks.

A report was submitted by T. H. Wiggin, as Acting Chairman of Sub-Committee 1-A, in March giving tentative recommendations for thicknesses and pressure ratings for pit cast pipe based on results of all investigations and tests made by and for this committee and especially in view of the knowledge gained from the trench load tests made at Iowa State College.

Specifications were obtained from the water works and gas works of London, Paris and Berlin. In the case of all six works cast iron pipes are used considerably thinner than are used in the United States for the same pressures.

The committee is withholding its final recommendations until completion of tests of 48-inch pipes, as mentioned below. The largest size previously tested was 20-inch, so results on the 48-inch pipes are needed to fix constants for the larger sizes.

Nine 12-foot lengths of 48-inch pipe were collected, eight of them by donation from the cities of Baltimore and New York and from the water company at Indianapolis and the other by purchase. Tests were started at the University of Illinois and Iowa State College on the strength of these pipes following the same methods as previously used in the tests at those universities on 20- and 12-inch pipe.

Sub-Committee 1-B, Bell and Spigot Dimensions of Cast Iron Pipe, including Lugs and Harnesses. A report was received from Prof. M. L. Enger, University of Illinois, on stresses in bells of cast iron pipe as determined by strain gage measurements of the bells while under external load.

In the manual to accompany the specifications it is planned to indicate good methods of arranging lugs and harness for tie bolts to hold bell and spigot joints under special conditions. Work was

carried on to assemble such a text and illustrations to be used in the manual.

Sub-Committee 1-C, Types of Pipe Other than Sand Cast. The committee adopted a final schedule of tests for pipes other than pit cast to be tested in the same way as pit cast pipes, with the provision that these tests on centrifugal pipe be made at the expense of the manufacturing company in each case. The business depression prevented the starting of any of these tests.

Sub-Committee 1-D, Fittings. The final report by Prof. E. W. Schoder on tests which he made for the committee at Cornell University on friction loss through fittings was followed by the Ricketts-Wiggin report applying these findings to a typical distribution system. Sub-Committee 1-D in 1933 adopted the Ricketts-Wiggin report as constituting the committee's conclusions on this work.

The Cast Iron Pipe Research Association submitted to the committee its recommendations for a short body fitting standard, together with notes of strength tests.

A study was begun by F. H. Stephenson under the direction of T. H. Wiggin, the general chairman, on strength and proper pressure ratings of fittings, including the fittings given in the present standards of the American Water Works Association, the American Gas Association and the American Standards Association Sectional Committee B-16 on Pipe Flanges and Fittings; of some proposed strengthened A. W. W. A. fittings; and of the proposed short body bell and spigot fittings recommended by the Cast Iron Pipe Research Association. Bursting tests made for the committee and for the Research Association together with data on fittings broken in service are being correlated in this study.

TECHNICAL COMMITTEE 2—METALLURGY, PROCESSES AND TESTS

Sub-Committee 2-C, Physical Tests and Test Specimens. Studies were carried on by T. H. Wiggin and F. H. Stephenson on physical properties of test bars. This was undertaken in order to prepare a specification for the existing 2-by 1-inch test bar providing for requirements for deflection at different increments of load on the bar. In this study use was made of records of breakage of over 1400 test bars gathered from New York City, Boston and Burlington, New Jersey.

TECHNICAL COMMITTEE 3—CORROSION AND PROTECTIVE COATINGS

Sub-Committee 3-A, Water Corrosion of Cast Iron. Since completion of tests at M. I. T. on corrosion of cast iron, research on this

topic has been continued by the Institute and arrangements are being made for publication of the results of both sets of tests.

Sub-Committee 3-B, Organic Coatings. Following the tentative draft of a specification for organic coatings issued in 1932, at the meeting in March, 1933, a special committee of manufacturers was appointed "to carry out, first, a canvass of the field of accelerated tests, to make comparisons between them, and to recommend one accelerated test for adoption; and second, to get such accelerated tests of the committee's specification coating, in comparison with the coatings now made by the various shops, made under the direction of the special committee, and to submit the proposed coating specification to the members of the sub-committee for letter ballot provided that the conclusions of the special committee on accelerated tests indicate the advisability of submitting the specification for approval." This special committee did not report by the end of the year.

Sub-Committee 3-C, Inorganic Linings. Following meetings of this sub-committee in March and in June the sub-committee has extended its specification for thickness of cement-mortar linings to cover 30- to 48-inch pipe and fittings, recommending a minimum of $\frac{1}{4}$ inch with a plus tolerance of $\frac{1}{8}$ inch for all sizes. If this is approved by the higher committees it will be added to the tentative specification for cement-mortar lining previously adopted.

A special committee on Bituminous Seal Coats for Cement Linings has recommended three cold asphalt paints for this purpose, all meeting the requirements of imparting no taste or odor to the water. One of these which has been under continuous test by the New York City Water Department for a year and a half has worked very well. The New York Water Department is also continuing long-time tests on the effect of cement linings, with and without bituminous seal coats, on Catskill water.

Cement lined pipes under test for this sub-committee at the Birmingham Water Works Company were reinspected during 1933 after three and a half years test and reports made on the condition of these pipes.

At the June meeting there was discussion of means of making the specification for cement mortar lining more of a product specification and less of a process one. Certain tests have been made by the American Cast Iron Pipe Company for the committee to this end.

Sub-Committee 3-E, Soil Corrosion. Pursuant to the previously adopted policy this committee has undertaken no work of its own, but its Chairman and the Chairman of Technical Committee 3 have

kept in touch with the work of the Underground Corrosion Section of the Bureau of Standards. As joint representative of the Sectional Committee and the American Water Works Association the Chairman of Technical Committee 3 spent three days at the Bureau, attended the conference on July 7, 1933 on the Bureau's draft report on Soil Corrosion Studies, 1932, and submitted a report on the scope, progress and outstanding results to date of the Bureau's soil corrosion and pipe coating investigation. This report was published in the February, 1934 issue of THE JOURNAL. A paper on Underground Corrosion by K. H. Logan, Chief, Underground Corrosion Section, Bureau of Standards, presented before the Sanitary Engineering Division, A. S. C. E., on January 18, 1934, was discussed in writing at the request of the author, by the Chairman of Sub-Committee 3-E. It is hoped that this paper and the discussions will be published.

PRIVATE WELL SUPPLIES

By John A. Bruhn, Homer Rupard and Neil Kershaw

(*Indianapolis Water Company, Indianapoils, Ind.*)

In the following discussion of private well supplies it is intended to cover primarily observations and information concerning wells where there is no regular examination by competent persons of the water produced. This excludes practically all municipal or public supplies. Comparisons will, however, be made between public filtered water supplies and private wells for the purpose of contrast and illustration.

The experience of the authors has been obtained through operation of sixty rock wells which serve as a supplementary or emergency source of supply for Indianapolis, and from their many contacts over a period of years with firms using private wells.

There is probably much variation in relative importance of the several factors entering into a discussion of private well supplies in different parts of the country. The nature of underlying geological formations affect materially the quality of water and also the depth at which it can be secured. While actual observations were limited to the wells of Central Indiana, many of the deductions and general facts are applicable to private wells wherever located.

In some instances wells are installed by individual concerns because there are no public supplies available. Under such conditions every known precaution should be taken to make certain the water is safe for drinking. It will often be advisable to treat the water. The kind and amount of treatment depends on the use to be made of it and the mineral quality of the supply obtainable. Consultation with persons who make the study of water supply quality their business is strongly recommended. Modern competition demands that every possible improvement be constantly made in the strength, durability, appearance, and physical properties of manufactured products. Many concerns have learned that when water is used in processing or treating its mineral content should be studied periodically. Water has been known to affect materially the characteristics of factory output.

Some private wells are installed for the sole purpose of saving money on the cost of water. Thorough investigation should always be made to make sure such economy is possible. The prospective and actual economies vary widely in both similar and different types of business. Each one has its individual problems. Contacts with plants in Indianapolis lead us to state that careful studies should be made of the peculiar conditions at each location *before* the large investment necessary for a private well supply is provided. The problem is a technical one in many respects and it is always best to secure advice from persons qualified along such lines who have no selfish motive such as equipment or service to sell.

PRODUCTION

Production problems are measurable in terms of their cost to the owner of the well supply. The costs of a well supply are made up of known factors, some of which may be accurately estimated, and others which are in the class of break-down or service failures, for which accurate costs are not known until the service has been restored.

Contacts with prospective and actual users of wells have convinced us that the average human has much faith in what he thinks, and is a confirmed optimist who believes that no adverse circumstances can occur in his own particular case to upset calculations.

In general, the prospective or actual users of wells do not avail themselves of information (on a technical subject about which they know little), they are very susceptible to high pressure salesmanship, and, to defend their judgment, they will refuse to recognize elementary factors of cost.

A brief outline of some of the principal factors entering into the cost of a well is as follows:

I. Investment or Capital Costs
   1. Drilling and casing of the well
   2. Purchase and installation of the pumping equipment
   3. Connecting the well supply
      a. Into the existing distribution system
      b. Into a special distribution system
   4. Approved cross connection with public supply
   5. Housing cost
   6. Failure and replacement of well

II. Operating Costs
   1. Power to operate pump
   2. Miscellaneous supplies
   3. Labor

III. Maintenance Costs
  1. Labor to remove, disassemble, repair and replace pumping unit and appurtenances
  2. Replacement parts
    a. Nature of well water promotes wear
  3. Costs incidental to loss of service during the outage for repairs

IV. Costs of Stand-by Service (Additional Capital Costs)
  1. Duplicate wells and pumping equipment
  2. Stand-by connection to the public supply

I. Investment or capital costs

The money to pay for the cost of well equipment must be obtained from some source. Our economic system is so designed that interest must be paid on money invested in equipment. The failure to charge such a cost against a proposed well installation cannot be excused by any reasonable or defensible arguments.

In addition to interest, a depreciation or retirement fund must be established to repay the principal of the money invested in the equipment, or to replace the equipment when it wears out, or when changes in the art make the old equipment obsolete.

There are two kinds of prices for drilling and casing a well. The purchaser may pay the well driller an agreed price for the job and take the risk of getting a producing well, or the purchaser may require that the well driller guarantee a certain minimum rate of production from the well before payment is made for the work. Naturally, the well driller must add to his price to cover his risk. Also let us note here that any guarantee of production is for a limited period only and not for an indefinite length of time. It is preferable that well drilling be done on the basis of a guaranteed minimum production, and this guarantee should extend over a sufficient time, a year if possible, to allow any possible defects in the well driller's work to appear.

The choice of pumping equipment is controlled by (*a*) the type of power available, (*b*) the capacity desired, (*c*) operating economy, (*d*) maintenance costs and (*e*) first cost.

In the majority of cases conditions (*a*) and (*b*) clearly indicate that electric motor driven, deep well centrifugal or turbine type of pumping unit should be selected. Because of the preponderance of units of this type, all the discussion in the cost portion of this paper will concern this one type of pumping unit.

Operating economy and low maintenance costs are desirable, and

cannot be obtained with a low first cost. The first cost must be high enough to cover the best in design, materials and workmanship before fairly economical operation and reasonably low maintenance costs may be obtained.

The majority of the sales arguments for these deep well turbine pumps are full of high pressure talk about details which have little actual effect on the sustained efficiency and the maintenance cost of the unit. Individual operating conditions are so different and records of performance are unobtainable from users so that the prospective purchaser usually has no reliable means of making an intelligent choice of equipment. Much well equipment is purchased by plant executives or operators who have had no previous experience with such equipment, and without obtaining advice from any who may be competent to select such equipment, or without checking references given by the vendor.

After a well has been drilled and the pumping equipment purchased and installed, the supply from the well must be properly connected into the existing distribution system, or into a special distribution system. If some uses in the plant require a certified public supply, then the well supply must be isolated from the public supply. If the well supply in connected into the same system as a certified public supply, then approved protective devices, which are expensive, must be installed to prevent the flow of any of the well water into the public supply mains. Piping costs money, and such costs are frequently not included in the estimates which are used to determine the economies of the well installation. In many instances piping costs are greater than those of either the well or the pump. In a recent case in Indianapolis the piping expense was $1,700.00, the well $1,000.00, and the pump $1,400.00.

Housing costs are seldom an important factor in the cost of a well installation. High vertical clearances and permanent means of pulling the pumping unit from the well are essential. If the well cannot be located in an existing building, then a special house, properly equipped must be provided.

The last item listed under Capital Costs (failure and replacement of well) is a very uncertain factor. A prospective well user must realize that a well is not a permanent fixture, with an indefinite life.

Anyone who is at all familiar with the behavior of steel pipe in wet and corrosive surroundings can realize the short life of such material. A well is several lengths of steep pipe driven into the

ground. Portions of that pipe are alternately wet and dry. The soil surrounding the pipe may contain cinders or other actively corrosive material. Local electrolytic or galvanic action is a common condition. Casings are frequently damaged during the driving. A crooked or out of plumb casing will cause trouble in the use of any pumping equipment except air lift. Wells with screens are subject to serious trouble and complete stoppage because of the clogging or failure of the screen.

These and other possible troubles with wells will affect the capital costs of a well installation in the two following ways. First, the most experienced well drillers and the best of materials must be used to guard against such troubles as far as possible. This costs more money. Second, the depreciation allowance for the investment in the well must be set up for a much shorter period than is usually admitted. This heavier depreciation allowance will be reflected in an increased annual operating charge.

To sum up the discussion of investment or capital charges, the fair consideration of all reasonable items of cost, with a proper allowance for each one, will build the capital costs up to such a point that the proposition will not seem nearly as attractive as would one which included only the bare bones of the cost of a well and a pump.

II. Operating costs

The operating costs of a well pump, expressed in terms of power, oil, miscellaneous supplies and labor, are usually very low when compared with the rates charged for the public supply. This comparison is the one which is played up to persuade a prospective well user that he is getting a bargain. Other items of cost are not mentioned or are passed over lightly.

The only comment on operating costs that is important from the view-point of this paper is the necessity for permanently installed measuring devices on the power input and the water output of the well pump. It has been our experience with private wells, that we can seldom reconcile the owner's estimate of the water his well is producing with the actual quantity produced. Lack of measuring devices means blind operation and no check on production or efficiency.

Operating labor is seldom a factor of cost, as the duties are generally assigned to an employee who is already on the payroll.

Records of the underground water level in Indianapolis, extending

over a period of more than fifty years, show a progressive lowering of the level. At one industrial plant, a well located within three hundred feet of White River has a pump with 100 feet of drop pipe, extending 70 feet below the low water level in the river. This pump loses suction about twice each minute and must be lowered before it will be effective. The operating engineer at this plant states that the pumping level has dropped at a rate of more than two feet per year during recent years. This condition means added cost in equipment, and a greater distance through which the water must be lifted, increasing the operating costs accordingly.

III. Maintenance costs

Deep well turbine pumps require frequent inspection and maintenance, if a unit is to operate anywhere near the original guaranteed efficiency.

The sustained efficiency of such a pump is dependent upon the clearances between the rotating and stationary parts. Wear of clearances in most pumps can be restored only by replacing the worn parts with new ones. A critical analysis of a pump to determine the cost of such replacement parts should be made before a unit is purchased. The nature of the water handled has an important effect on the wear of the moving parts in a pump. Several local installations have shown excessive rates of wear from such a cause.

Maintenance work on a deep well turbine pump requires the removal of all parts from the well and a complete dismantling of the unit. This requires several men, special rigging and time. It is by no means a simple, rapid job. Such work should be done at regular intervals and reasonable estimates of the cost be made for each particular installation. These must be considered in a study of operating costs.

The man in charge of the operation and maintenance of mechanical equipment at the plant of one of the largest users of private wells in Indianapolis, a man of forty years experience on that job, estimates the average cost of an overhaul of one of their well pumps at about $300.00. They have had to overhaul pumps after as little as two months service. This man states that the lowered water level, calling for much deeper pumps, has seriously shortened the time that a pump will run between overhauls.

The cost of water service, however obtained, during the outage of the well pump constitutes an important item of the maintenance costs, and it is one which is seldom thought of.

IV. Costs of stand-by service

This is properly a capital charge. It has been separated from the rest of the discussion because it is an item which few think of until an emergency arises.

A public water supply is obligated to maintain pumping capacity equal to several times their average load, and sufficient to carry the maximum load with their two largest units out of service. The magnitude of the investment in so much equipment is obvious.

A private well user will calmly proceed to install a single unit, having a very low degree of mechanical reliability, and then think that he has no need for any reserve or stand-by capacity.

One of two things should be done. Either the well and pumping equipment should be in duplicate, or a stand-by connection with the public supply should be maintained and paid for. Both of these safeguards are neglected or ignored with surprising frequency.

Two examples may be cited. First, people in one location in Indianapolis, decided that they should install their own well. The matter was studied carefully by all parties, and the costs of the private supply were such that the only possibility of a saving was by eliminating all stand-by connections to the public supply. The project went ahead, and after its completion and apparent successful operation, stand-by connections were maintained, with the result that the annual cost of water was actually increased.

The second instance is that of a local charitable institution, housing more than two hundred old persons. A well and pumping equipment were installed for reasons of economy. The public supply was disconnected. One night, after the well had been in operation less than six months, an emergency call was received by the Water Company. The pump had failed and the institution was out of water. They have now contracted to pay for stand-by service from the public supply and have installed the required protective devices for the cross connection. As a result, they now have the cost of repairing the pump, of stand-by service, of installing the cross connection, and the serious inconvenience of being without water, all added to their expected cost of operating the well.

This discussion of production costs may be summed up by a simple plea for an impartial investigation and analysis of all factors of the costs of a private supply before investing good money in it. If savings are evident, then it would be a good investment, but there is no profit in spending money on the basis of partial and misleading information.

QUALITY

With the engineering requirements of production and cost discussed we will now proceed to the matter of quality of private supplies. It seems that from the consumers standpoint the only requirement is that water be cold, clear and have a good taste. All of these may be obtainable from a well supply, but none are true criteria for the determination of quality. The general attitude of the owners and operators of private supplies is that the supply is safe as long as it has not caused an epidemic. This statement "safe as long as it has not caused an epidemic" bears repeating as it was found to be the consensus of opinion in a recent survey of privately owned and operated supplies in the City of Indianapolis.

This idea is false. Such supplies have caused epidemics which could have been prevented had reasonable care been exercised. The public supplies normally are more reliable for they have regular inspection and recognize clearly their responsibility. Courts have held that the owner of any private supply is liable whenever a water borne disease can be definitely traced to his negligence. The frequency of these unfortunate occurrences only emphasizes the necessity of careful, regular inspection to detect and prevent them.

In water works literature numerous instances of epidemics from private supplies have been cited caused by seepage, sewage pollution, corroded and faulty casings, abandoned wells, unsealed annular openings, cleavages in the rock as well as numerous other indirect causes. Typhoid fever, dysenteries and diarrheas are the most common of the water borne diseases.

These epidemics may be classified into two types, the preventable and the unpreventable. Under the first type falls the unsealed annular opening—the opening between the drop pipe and the casing. This is a place where sewage pollution and flood water can enter. With the most popular deep well pumps of today, the submerged centrifugal or turbine type, the common practice is merely to cover this opening and not definitely to seal it.

With an air lift well it is extremely important that care be exercised in the location of the compressor intake. The intake should be above the ground level to prevent surface and sewage contamination.

Corroded and faulty casings have also contributed their share of grief. These difficulties can be corrected, but only by replacement of the casings. This is frequent practice and is generally carried on at the expense of the quantity of supply available as frequently it is necessary to drop a new casing of smaller diameter inside the original.

These contaminations are all truly preventable, but only to the extent of the frequency of examinations to indicate them. Private supplies are seldom if ever checked for quality.

The other types of pollution are far more dangerous in that they are unpreventable and are generally detected after the damage has been done.

Rainfall is the primary source of the well supplies. At peak flood periods the stream flows are only a small portion of the total rainfall—the soil acting as a balancing reservoir. The water that does not flow directly into the streams passes through the soil, gravel and sand and finally a portion of it finds its way through the limestone or rock. In the course of travel the water is adversely mineralized to a degree depending upon the depth and kind of layers it has passed through. Along with mineralization it is possible to pick up sewage pollution from leaking sewers, privy vaults as well as surface drainage. To be sure these contaminations may be filtered out on passing through sufficient sand, gravel or limestone. The main difficulty here is the uncertainty of the filtering media. The solution effect of the water on the limestone or rock that it is passing through is ever producing unknown changes which in time may lead to serious difficulties. The solution effect depends to a great extent on the pumpage draft lowering the water head, drawing water from the area overlying and down into the limestone or rock area.

Chloride Content

Chloride chlorine in water is the product of soluble chloride in rock (which is rare in this region) and the excretory processes of warm blooded animals—urine containing approximately 1 percent sodium chloride. The chloride chlorine then offers a quick method for the determination of latent dangers. The normal chloride content of sewage in Indianapolis is ± 125 p.p.m. Part of the discrepancy in the total amount of water used and the amount of sewage accounted for is from leaking sewers. This water also finds its way down into the gravel and limestone areas. High chloride content in a well supply then indicates this water to be partly filtered sewage filtered through a totally unknown or uncontrollable filter. When the chloride approaches the normal content for sewage in a particular district the nearer it approaches filtered sewage—where the supply exceeds the normal sewage content local wastes are responsible. Normal deep well supplies produce water of low bacterial content and a chloride content less than 25 p.p.m. The effect of concentration of sewer

systems on the chloride content is shown in figure 1. With a few exceptions the chloride content of the well supplies within the inner rectangle range from 75 to 100 p.p.m. and would be considered of doubtful quality. Within this rectangle are also a number of wells with a chloride content over 100 p.p.m. Between the inner and outer rectangles the chloride content ranges from 25 to 75 p.p.m. and is considered to be materially affected by sewage. Outside of the two rectangles with hardly an exception the chloride content

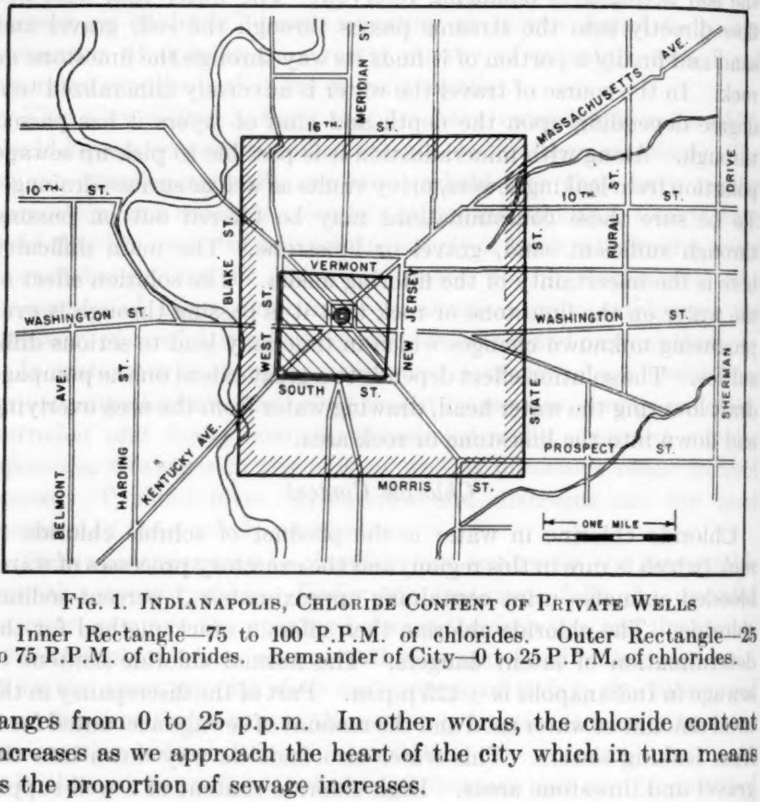

FIG. 1. INDIANAPOLIS, CHLORIDE CONTENT OF PRIVATE WELLS

Inner Rectangle—75 to 100 P.P.M. of chlorides. Outer Rectangle—25 to 75 P.P.M. of chlorides. Remainder of City—0 to 25 P.P.M. of chlorides.

ranges from 0 to 25 p.p.m. In other words, the chloride content increases as we approach the heart of the city which in turn means as the proportion of sewage increases.

Shooting

Epidemics from private supplies have also been caused by "shooting" or dynamiting a well. This practice is resorted to to increase well production when the flow has dropped off. This may cause cracks and rock cleavages that will allow contaminated water to pollute an

otherwise safe supply. A neighboring supply may be contaminated without the neighbors knowledge of the shooting of the well in question.

Abandoned wells

The abandoned well is of major importance in that it is a direct connection to the water bearing areas. It is logical to assume that, when a well is abandoned, generally the intention is merely to take the well out of service until some future period. Regardless of what the intention is, the well should be capped or plugged to avoid contamination of other supplies. Where it is definitely known the well will not be used again it should be plugged to the rock level with concrete and the remainder filled with sand or gravel for only too frequently casings rot off and their location is forgotten or lost. A most striking instance of this type of hazard was that in Fond Du Lac, Wisconsin. Here a well was abandoned and in time the course of a polluted stream was diverted to flow over the abandoned casing. The polluted stream water found its way into the city supply through this abandoned well causing an epidemic of 1000 cases of dysentery, 50 cases of typhoid fever, and 3 deaths. If proper care is exercised in abandoning a well this type of epidemic can be prevented. Supplies have been and still will be contaminated, however, due to the lack of knowledge of the existence of the abandoned well. It is not uncommon to find that an abandoned well has been used as a dry well or sump. On the recent private well survey in Indianapolis two such cases were found.

The final sealing between the casing and rock is very uncertain and so located to make inspection impossible. With a poor seal, seepage around the casing gives rise to pollution possibilities.

After all has been said on the subject of preventable and unpreventable types of pollution it remains that it is only a matter of time until the pollution occurs.

Hardness

While the bacteriological qualities are seldom checked, the chemical characteristics of the private supply are much more closely watched, probably due to the actual outlay in dollars and cents. The U. S. Geological Survey classifies waters into hard and soft, the dividing line following along certain boundaries by reason of their underlying geological formation. Indiana in this classification is along with

Arizona, South Dakota, Nebraska, Kansas, Oklahoma, Iowa, Illinois and Florida of the hard water type, having hardness ranging from 12 to 29 grains per gallon.

Some manufacturers have few requirements as far as water is concerned, but practically no industry would fail to be affected by hardness for boiler use. Certain districts in the U. S. are known for a particular industry and this industry frequently has definite water requirements.

In Indianapolis the well surveys have shown wells with hardness ranging as high as 44 grains per gallon with the average above 30. Hardness is practically all due to calcium and magnesium salts and is an inconvenience to the private individual as well as to industry. When the hardness is not a definite disadvantage for industry it is a soap consumer for the individual. It has been calculated that for each grain per gallon of hardness per 1000 gallons water used, it requires 3.4 pounds of soap. It must also be borne in mind that the total solid and hardness content of the supply as the well is first drilled is no assurance that it will remain at that figure as records show in this particular region the normal tendency is toward a progressive increase in mineral content. Other items of importance due to hardness are increased fuel bills, pipe and valve repairing, higher laundry bills, along with other numerous indirect costs.

Red water is not only due to the naturally present iron of the water, which normally does not fall below 1 and often is found to be as high as 4 and 5 p.p.m. in well supplies, but to the corrosive effect upon to the pipes and service tanks through which it flows.

Corrosion, according to present hypotheses, depends on two things, (1) the presence of hydrogen ions in water and (2) the presence of dissolved oxygen. Hydrogen ions are increased by the presence of carbon dioxide which in turn increases the corrosive tendency, although the carbon dioxide is of minor importance.

COMPARISON OF PRIVATE AND PUBLIC SUPPLIES

In Indianapolis practically all of the public water supply is filtered, coagulated by means of alum, chlorinated, and treated with carbon and ammonia sulphate. An average of 50,000 tests are made annually to guarantee its purity and known quality. As previously mentioned, 60 deep wells supplement the surface supply in certain seasons and the production of each is regularly examined to insure good quality. Because of increasing difficulties with discoloration

resulting from iron it became necessary to curtail the use of these wells several months ago. Constant studies are in progress to provide under good pressure at all times, a supply of water which is entirely satisfactory for industrial, commercial, and domestic use.

It is the policy of the Company to give information and advice concerning water supply to all present customers and prospective ones on request. Matters involving quality, pressure, volume, and so forth are handled through the Commercial Department in cooperation with the Filtration, Engineering, Distribution, and Pumping Departments. Often we are able to be of valuable assistance to consumers and they seem to appreciate the help. Savings can sometimes be made by recirculating water which it is possible to use more than once. It may be practical in certain plants to install atmospheric cooling towers or to secure lower temperature water by mechanical means. Other detailed recommendations have been made at various locations.

Through contacts with customers we sometimes find *when it is too late* that they have failed to analyze thoroughly their water requirements and to investigate carefully seeming economies before installing private wells. As a result they are actually paying more than they would to use water only from the public mains. The resale or scrap value of pumping equipment is low so they naturally feel forced to continue use of the equipment until a break-down occurs. Among other reasons given to justify the expenditure the most common one is the claim of pumping much more water than is actually produced. If all costs are ascertained, among them being

Energy and demand power charge
Maintenance (labor and material)
Depreciation
Interest and taxes on investment
Auxiliary or stand-by service
Additional softening cost
Pipe and valve replacement sometimes necessary due to action of deep well water
Protective equipment required by health authorities
Excess capacity for peak demands

the original proposal submitted by a person with something to sell may not be as good as it seems.

Many illustrations could be pointed out of private well supplies which did not prove profitable. The following local examples should

be interesting. Comparative figures on the annual costs of private versus public sources at one location are:

Private well

Total cost (well and connections)	$6,130	
Fixed charges:		
A. Depreciation	$367.80	
B. Maintenance	429.10	
C. Interest	429.10	
		$1,226
Electric power		575
Stand-by cost for public supply		504
Total		$2,305

Public supply only

Cost of water used during preceding year (usage about the same)	$1,335
	$1,335

These figures show that the private well supply cost almost twice as much as the public supply, if everything is considered. Most of the water is used for irrigation and the 57° well water has been found less satisfactory than the warmer public surface supply. Since many persons drink water at this location the lack of controlled quality is also important. In this particular case the first deep well was a failure and resulted in a financial loss to the well driller who had signed a guaranteed production contract.

At another place the owners of the business decided to drill a well for economic reasons. They anticipated no trouble in securing a producing well because their property was located between two nearby streams. Therefore, the well driller was hired on a "no guarantee" basis and the project was finally abandoned in despair after vainly drilling three 6-inch non-producing wells ranging in depth from 60 to 330 feet. Drilling expense totalled over $1,000.00.

In our part of the state the cost of softening well water is about 6 cents per thousand gallons more than for softening the public supply. If all costs are considered it is, without doubt, false economy to attempt to soften water from local deep wells. This is proven by the fact that not one laundry in Indianapolis uses private well water. In addition to the more frequent regeneration of softeners required the iron in local deep well water builds up on the zeolite mineral,

decreases its softening power, and shortens its life. In spite of this fact one of the large buildings in our city is continuing to soften its well supply at an economic loss to attempt to justify the original expenditure for private well equipment.

(Presented before the Indiana Section meeting, April 12, 1934.)

POOR SPEECH AT TECHNICAL MEETINGS[1]

By "Auribus"

Most, if not all, of the Institutions are free from general criticism, but in one respect serious ground exists for genuine complaint. Much too little attention is paid by the powers that be to the standards of the delivery of papers, and of the subsequent discussions.

To those who are accustomed, even in quite a humble way, to public speaking, and at the same time are regular listeners at technical meetings, this shortcoming appears to be little short of deplorable. The trouble is not confined to any one institution, or section; all suffer alike, if in varying degree. From this one is forced to the disappointing conclusion that, among technical men as a whole, the faculty of public address is pretty well left to its own resources. Bearing in mind the high technical merit of the subject-matter generally, one finds oneself leaving the usual meeting with a feeling of irritated disappointment, realising that what otherwise would have been a delightful evening has been hopelessly spoiled.

The spoliation, moreover, is twofold; for, in addition it hits at one's pride of calling (still a motive force, despite slump and cynic). Poor delivery of a paper, and/or of the reply to it, conveys to the earnest listener the feeling that a lack of common education exists, countered though this may be, to some extent, by the quality of the contents of the paper. Consequently, one wonders whether a technical training must invariably preclude any other kind of training. This leads in turn, and with something of a jolt, to the realisation that one's own examination papers ignored entirely the verbal side of the matter. More strangely still, the next thought, is that each institution exists largely for that very verbal dissemination, the ineffective execution of which is the cause of the trouble.

SPEAKING OR READING?

Few papers are read in full; the I.E.E. at least definitely discourages this practice. A résumé by the speaker, lasting not more than thirty to forty minutes, is preferred. To memorise this is the simplest

[1] Extract from "The Electrical Review," January 26, 1934.

thing in the world. The few necessary and simple rules of mental connection can be found in any low-priced volume on public speaking, and their application is far easier than the construction of the résumé itself. It is astonishing that such simple, but vital adjuncts to technical delivery seem to be so entirely neglected.

The ideal is to make all remarks as nearly *ex tempore* as possible; this can only be done by making adequate use of the natural functioning of any ordinary mind. Which is to be preferred—a free, unfettered face, constantly and actively on the audience, or a dreary monotone reading, eyes glued to the stand, voice reflected to the chairman's back, and a demeanour generally suggesting a prayer to Heaven that it will soon be all over?

Remarks which are read possess one vital defect: they kill the interest of the audience. Only the most expert elocutionist can prevent this, and even he has a hard task. Compare the attitude of an accomplished after-lunch speaker, even though the style of meeting be different. He conveys no idea of studied preparation. He keeps his figure constantly alive. His eyes rest on every member present in short turn, sufficiently adequate, but no more than just adequate, to convey to every hearer that feeling of gentle deference toward him, so necessary to his assimilation of the main content of the spoken word. He who reads his remark simply cannot do this.

In these times this idea of deference towards assimilation is peculiarly important. Few men attending an institution meeting can find time to study in detail matters outside their general duties, as in their days of graduateship and lighter responsibilities. To them the meetings are most welcome events, for they provide the opportunity needed "to keep them in touch."

All the more intense is the disappointment when it does occur; and rarely do technical speakers realise that this feature as a whole endows them to start off with one supreme advantage. The audience is willing to listen to them before they commence. Verbal trickery as a means of forcing artificial interest is rendered quite unnecessary, and one of the ordinary speaker's major worries does not clog the technical man from the outset.

APATHY AND ENTHUSIASM

A recent lantern address in Birmingham exemplified the point particularly. More than merely modern, the subject visualised a particular technical future. As a result the speaker had a gratify-

ingly large audience, which animated its preliminary tea-taking by keen anticipation of the nature of the expected remarks. After twenty minutes, some left the room; by the end of the address the audience had dwindled by half. Read in its entirety, the paper, worse still, had been constructed quite without regard to the interruptions which would essentially occur as the speaker periodically left the dais to point to the screen. To cap all, each time the speaker did move to the screen, he spoke straight into it, to the direct exclusion of his audience. The resulting discussion, carried on by the few who retained any interest at all, showed most obviously that even they had missed half of the essential points which the lecturer had indicated particular desire to stress.

Few things are more disastrous than the omission to look an audience, and particularly a questioner, in the face. Yet this might be singled out as the fault most common to all technical meetings. Dropping eyes almost invariably prelude shifting feet and closing lips; all conveying the irritating suggestion of uncertainty, unconcentrated thinking, and sense of requiring to answer because one must, not because one loves to. Against this, the confident speaker will positively poise on his toes when replying, through sheer enthusiasm for his subject. Most technical men, deep down, possess the same enthusiasm, but the expression of it consciously or unconsciously is lacking.

No one doubts for a moment that the consciousness of his responsibility toward his particular audience, weighs heavily upon a technical speaker, and this is indeed evidenced by the very careful preparation of subject matter, which is generally the case.

It is surely the duty of the responsible governing bodies to insist that defective delivery of papers shall be rectified.

TREATMENT OF PUBLIC WATER SUPPLIES AND THEIR INDUSTRIAL USE, 1922–32

By W. D. Collins, W. L. Lamar and E. W. Lohr

(United States Geological Survey, Washington, D. C.)

The revision, after 10 years, of a report on the industrial utility of public water supplies in the United States[1,2] afforded an opportunity for comparison of conditions of source and treatment of the larger water supplies in the United States in 1922 and 1932. The revision carries data for more than twice as many places as the original report and gives more complete data for the places included. Part of the increase in the amount of information included is due to the advances in methods and control of treatment.

Throughout the report the term "place" is used to designate a city or district listed in the table of data. Of these "places" 67, with a total population of 2,431,600, are either included in "districts" or are served from the supplies of other cities. There are also 2,834,000 consumers outside the places listed who are served from the supplies that are described in the report.

The water-supply systems described are predominantly owned and operated by municipalities or water-supply districts, but the systems of 69 places, with 4,056,000 inhabitants, are owned or operated by large holding companies, and the systems of 84 places, with 4,166,000 inhabitants, are independently and privately owned.

Table 1, from the report for 1932, indicates in a general way the source and treatment of the supplies serving 46 percent of the population of the United States. The data are necessarily somewhat generalized, because several places have supplies from dissimilar sources and have different kinds of treatment for different parts of their supplies. The table may be misleading if one does not remember that the data refer only to the larger cities in the United States.

[1] Collins, W. D., The industrial utility of public water supplies in the United States: U. S. Geol. Survey Water-Supply Paper 496, 1923.

[2] Collins, W. D., Lamar, W. L., and Lohr, E. W., The industrial utility of public water supplies in the United States, 1932: U. S. Geol. Survey Water-Supply Paper 658, 1934.

The proportion of ground-water supplies to surface-water supplies is undoubtedly much greater for the places not included in the report. Although the 40 places served with softened water represent a decided advance over conditions in 1922, there is still room for improvement

TABLE 1

Source and treatment of the public-water supplies of the larger cities in the United States in 1932

SOURCE AND TREATMENT	PLACES	POPULATION SERVED	
		Thousands	Percentage of total population of United States
Surface water:			
No treatment other than chlorination	160	21,932	17.9
Coagulation without filtration	6	126	0.1
Filtration without coagulation	11	2,216	1.8
Filtration after coagulation	241	19,695	16.0
Filtration and softening	32	3,752	3.1
Total surface supplies	450	47,721	38.9
Wells less than 100 feet deep, infiltration galleries, and springs:			
No treatment other than chlorination	64	2,223	1.8
Iron removal	13	391	0.3
Softening	3	203	0.2
Total shallow ground supplies	80	2,817	2.3
Wells 100 feet or more deep:			
No treatment other than chlorination	119	5,473	4.5
Iron removal	16	575	0.4
Softening	5	110	0.1
Total deep ground supplies	140	6,158	5.0
Total ground supplies	220	8,975	7.3
Total supplies	670	56,696	46.2

as regards the hardness of the supplies. This can be seen from table 2, which must be recognized as applying to the larger places in the different States. Many of the 17,788,000 consumers in the two groups served with water having hardness over 120 parts per million will be benefited eventually by softening of their supplies.

An indication of the benefit received from softening is given in table 3, in which the consumers in the 40 places where softening is

TABLE 2

Number of persons using water of certain degrees of hardness from large public supply systems in over 600 cities in the United States

RANGE OF HARDNESS (PARTS PER MILLION)	POPULATION (THOUSANDS)		
	Surface water	Ground water	Total
1-60	19,057	1,315	20,372
61-120	16,413	2,123	18,536
121-180	9,062	1,517	10,579
180+	2,804	4,405	7,209
	47,336	9,360	56,696

TABLE 3

Numbers of consumers in 40 places using softened water in different ranges of hardness and the corresponding numbers if the supplies were not softened

RANGE IN HARDNESS (PARTS PER MILLION)	THOUSANDS OF CONSUMERS	
	Softened water	Raw water*
51-60	23	—
61-80	949	—
81-100	1,911	—
101-120	536	—
121-140	354	459
141-160	185	790
161-180	22	1,081
181-200	29	238
201-250	56	499
251-300	—	714
301-400	—	43
401-500		—
501-600	—	210
601-700		—
701-800	—	31
	4,065	4,065

* Filtration without softening does not change the hardness of the raw water.

practiced are divided into groups as they now are and as they would be with unsoftened supplies. The grouping shows that at these

places no raw water having a hardness of less than 120 parts per million is softened and that most of the softened water is served with hardness less than 120 parts. Calculation of the weighted average hardness for the 4,065,000 consumers gives 212 for the raw water and 96 for the softened water, which indicates a notable saving in soap consumption and in the other expenses that accompany the use of hard water. The results in the table are necessary approximations. The figures for hardness of the individual supplies and sources are based on averages of analyses over a period of a year, or on single analyses supposed to represent average conditions, or for a few of the untreated waters (no extremes) they are merely estimates based on data for similar sources.

In 1922 there was not much reliable information as to the pH of the different public-water supplies, and its adjustment was not very common. One of the most frequent complaints about the report for 1922 related to the lack of data for pH. There are still several water supplies for which data on the pH could not be obtained, but reports were available in 1932 for most of the places where there is any great need for the information. Treatment for the adjustment of pH was reported for 96 places, with 7,768,000 inhabitants. Moreover, at each of the softening plants the treatment is normally so conducted as to keep the effluent within some definite range of pH. This gives a total of 11,833,000 consumers supplied with water of which the pH is under control.

Chlorination and treatment for the prevention of tastes and odors are not mentioned in the descriptions of individual supplies for 1922 or 1932. Chlorination is omitted because it is so nearly universal and has very little effect on the industrial use of the public supplies. Treatment for tastes and odors is not mentioned in either report because in 1922 it was not common and in 1932 it had hardly become standardized, although the advances in the prevention and removal of tastes and odors have been among the most notable of the improvements in the general character of water supplies from 1922 to 1932. Neither the tastes and odors nor the means for their prevention have very much effect on the industrial use of the waters.

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Fundamental Principles of Orifice Metering. K. H. Warren. Instruments, 6: 10, 187, October, 1933. A flow meter can be made by inserting an orifice plate in the line between a pair of flanges and connecting pressure taps upstream and downstream from the orifice to the ends of U-tubes. Formulas and coefficients are presented for computations of flow.—*H. E. Babbitt.*

Sulzer-Engined Pumping Station at Staines, England. Anon. Oil Power, 23: 337, 252, October, 1933. Oil engine power has been adopted for recent additions to pumping equipment of South West Suburban Water Company, near London. Details of pumping station are described and illustrated. Plant comprises two main sets for high lift, two low-lift pumps, and accessories. Each main set consists of a 5-cylinder, airless injection, 4-stroke cycle Diesel engine, rated at 500 B.H.P., driving a 2-stage centrifugal pump with capacity of 4 million gallons (Imperial) per day.—*H. E. Babbitt.*

What Kind of Deep Well Pump? Review of A. R. E. A. Committee Report. Railway Engineering and Maintenance, 29: 11, 545, November, 1933. Summary of most recent improvements in equipment for deep well pumping, with review of the practical considerations governing selection of equipment. Types now generally used are the single, or double, plunger displacement pump, the turbine pump, and the air-lift. Displacement pumps are suitable for from 50 to 300 gallons per minute and for depths not greater than 300 feet, with maximum speed of 25 r.p.m. Overall efficiencies will vary between 40 and 60 percent. The turbine pump is suitable for capacities between 50 and 6,000 gallons per minute and for all depths up to 500 feet. Efficiencies up to 60 percent can be obtained. Air-lift may be considered for a wide range of pumpages and for depths greater than other pumps. They are suitable for crooked holes, or in wells producing sediment. Efficiencies between 25 and 40 percent may be expected.—*H. E. Babbitt.*

Welds Water Main 40 Feet Under River. Anon. Welding Engineer, 18: 11, 19, November, 1933. Account of welding of large crack in 72-inch cast iron water main under Hackensack River in New Jersey.—*H. E. Babbitt.*

Trial Load Method of Masonry Dam Analysis. I. E. Houk. Western Construction News, 8: 17, 455, November, 1933. Method furnishes accurate means

for determining stresses in large masonry dams and supplies satisfactory basis for design. All curved dams of appreciable size, whether of massive-curved, gravity type or of thin, sharply arched type, or of straight gravity design, should be analyzed by this method. Effects of tangential shear, twist, foundation and abutment deformations, radial cantilever sides, Poisson's ratio, and temperature changes, are important and should be analyzed. Method assumes (1) that structure acts as a monolith; (2) that horizontal water load is carried by a system of horizontal, or arch, elements and one of vertical, or cantilever, elements; and (3) that water load is divided between these two systems so as to satisfy the conditions of equilibrium and of geometrical continuity in all parts of structure.—*H. E. Babbitt.*

El Capitan Water Supply Dam for San Diego. R. P. BRYAN. Western Construction News, 8: 18, 485, December, 1933. With construction 77 percent complete in point of cost, the $2,332,800 El Capitan Dam, a rock-embankment-hydraulic-fill structure, 217 feet high above stream bed, with crest length 1,100 feet, stream bed stripping, 25 feet deep, and maximum cut-off trench 52 feet below stream bed, is now within one year of completion.—*H. E. Babbitt.*

Bacteriophage Water Purification. Editorial. Jour. Amer. Med. Assoc., 101: 10, 781, September 2, 1933. Discusses presence of bacteriophages in contaminated waters and opinions advanced as to their effect on pathogenic bacteria in water supplies, or in swimming pools. Hitherto there has been a lack of good experimental evidence. Summary is given of recently reported tests by Prof. PAUL J. BEARD (J. Infect. Dis., 52: 420, May-June, 1933), who studied the action of numerous anticolon and antistaphylococcus bacteriophages on known bacteriophage-susceptible strains under various conditions closely simulating those of natural water supplies and routine methods of storage and treatment. Data indicate that bacteriophage is not likely to participate significantly in the reduction in bacterial numbers in polluted water or in sewage.—*J. H. O'Neill.*

The Outbreak of Amebiases in Chicago During 1933. H. N. BUNDESEN, F. O. TONNEY, I. D. RAWLINGS. Jour. Amer. Med. Assoc., 102: 5, 367–372, February 3, 1934. History of the outbreak of amebic dysentery which occurred during latter half of 1933, and findings of ensuing investigation. Report on same by special committee, which includes comments re laboratory data, sanitary engineering survey and epidemiology, with recommendations and conclusions. Special note is made regarding cross-connections and plumbing defects. Detailed outline is given for laboratory examination and diagnosis. Editorial in same issue stresses importance of close supervision to detect and control hazards relating to water supply, sewage disposal, food handling, ventilation, and similar problems.—*J. H. O'Neill.*

Drinking Water as a Cause of Asthma. Jour. Amer. Med. Assoc., 102: 17, 1435, April 28, 1934. Abstract of article in Journal of Allergy, 5: 197, January 1934, by S. H. WATSON and C. S. KIBLER, who "report a case in which it was proved that drinking water was the cause of asthma and so-called functional

colitis." The chlorine radical is considered to have been the cause.—*J. H. O'Neill.*

The Biology of the Vienna High Spring Water. MAX ENGLING. Abh. a.d. Gesamt. d. Hyg., 7: 28, 1931. The pure water of the Vienna high spring system is obtained from a large spring district through two mains. Routine biological sampling device consists of a bottle with the bottom cut off and the inverted neck covered by a fine screen covered with cotton wool. At equal water pressures, of about 30 cm. water column, quantity of water which can be filtered through such a filter before clogging is a measure of amount of suspended matter. From 3000 to 4000 liters of pure water can be so filtered, but scarcely one-tenth as much of impure water and only one one-hundredth as much of very impure surface water. Experience with the high spring water during some years indicates that number of organisms of animal or plant origin isolated from 1000 liters of water parallels bacterial count, as does also number of non-living organic particles, such as pine pollen grains. In three years, 1.65 m.g. of water yielded 19360 organisms divided into 50 different species. Increase in average count during period of observation is ascribed to increased tourist traffic through the spring district, which is to be limited by official action in future.—*Manz. Translated by Selma Gottlieb.*

Contribution to the Question of the Solubility of Lead in Water. JULIUS ZINK. Zeit. f. anal. Chem., 91: 7–8, 246, 1933. Eighty-seven to 106 p.p.m. of lead dissolve in 24 hours in carbon-dioxide-free distilled water containing 8.4 to 9.0 p.p.m. of dissolved oxygen. Solution has decided alkaline reaction (pH 9.5 to 9.7) and becomes turbid on admission of carbon dioxide. In distilled water containing dissolved oxygen and 8 to 10 p.p.m. of free carbon dioxide, a milky turbidity developes, first on the lead, but later throughout the liquid; 115 to 122 p.p.m. of lead go into solution, partly as carbonate and partly as hydroxide. When the water contains a large amount of carbon dioxide, neither turbidity nor alkaline reaction is observed and only small amounts of lead go into solution: with 64 p.p.m. of free carbon dioxide, 7.3 p.p.m. of lead, and with 131 p.p.m. of carbon dioxide, 11.9 p.p.m. of lead. In a solution of sodium bicarbonate at pH 8.6, only from 0.23 to 0.3 p.p.m. of lead dissolved. Large quantities of chloride decrease the amount of lead dissolved and hinder the appearance of alkaline reaction. With chloride content of 28 p.p.m., the solution contained 47 p.p.m. of lead at pH 9.5; with chloride content of 266 p.p.m., only 1.3 p.p.m. at pH 8.0. Sulfate and nitrate show same effect, but to lesser extent.—*Manz. Translated by Selma Gottlieb.*

Purification of Water with Activated Carbon. IR. N. D. R. SCHAAFSMA. Ges.-Ing., 56: 9, 101, March 3, 1933. Experiences with superchlorination and filtration through activated carbon, Hydraffin R II, in Dutch East Indies. Feed water of Tjikini swimming pool in Batavia, treated with Caporit equivalent to 3.5 p.p.m. of free chlorine, was completely dechlorinated by filtration through 2.6-foot carbon bed at rate of 47.6 feet per hour. In ice factory, well water was coagulated with alum and potassium permanganate, filtered, chlorinated to an excess of 0.5 to 1.0 p.p.m. and, before running into freezing tanks,

dechlorinated by passage through carbon filter. For a year this filter furnished water with chlorine content of not over 0.1 p.p.m.; at end of this time it was given its first regeneration with 3 percent calcium chloride solution and 5 percent sodium carbonate solution. Filtration through carbon reduces permanganate consumption from 2.2 to 0.8 p.p.m. and taste producing substances are eliminated. However, in another case no reduction in organic matter was observed after super-chlorination and filtration through carbon. Experiments made in Pontianak with peat water showed that superchlorination followed by filtration through Hydraffin R II removed residual humin substances not eliminated by coagulation with alum and potassium permanganate, but did not remove such organic substances as sugar, glycerine, and alcohol.—*Manz. Translated by Selma Gottlieb.*

Use of Activated Carbon in Slow Sand Filters. P. Smit. Ges.-Ing., **56:** 5, 52, February, 1933. In evaluating activated carbon it is advisable to establish adsorption curves by testing with dyes and other substances. The adsorption capacity is a characteristic not only of the carbon but also of the dye; some types show a much stronger adsorption capacity for some dyes than for others. They can scarcely therefore be characterized by their half value period. In the works of the N. V. Alblasserdamsche Waterleiding Mij in Alblasserdam, performances of 1.2 and 0.3 inch layers respectively, of "Aktivit" have been tested, on the Kil water system for 20 months and on the Gravendeel system for 8 months. Carbon layer is placed 16 inches under sand surface and, in comparison with control filter, produces no additional loss of head. Effluent had an appreciably better odor and taste and 30 percent better bacterial count. Potassium permanganate consumption of carbon-filtered water varied between equivalence with control filter and zero. From this variation and from calculation of total amount of organic matter removed by carbon (the weight removed exceeding that of the carbon), auto-regeneration of the carbon is assumed.—*Manz. Translated by Selma Gottlieb.*

The De-aëration of Boiler Feed Water with Sulfur Dioxide and Sodium Sulfite. E. Seyb and W. Wesly. Arch. f. Wärmewirt. u. Dampfk., **14:** 2, 29, February, 1933. Reaction between dissolved oxygen and sulfite proceeds more rapidly the purer and lower in salts the water, the higher the temperature, and the greater the excess of sulfite. In distilled water at 20°, the theoretical requirement of sulfite is only 50 percent used up after 10 minutes and only 80 percent after 6 hours. At 50°, reaction is complete after 90 minutes and at 85°, it is practically instantaneous. In more highly mineralized waters, only 27 percent of calculated amount had reacted after 27 hours at 50°; at 85°, 80 percent had reacted after half-an-hour. With a 100 percent excess of sulfite and in presence of small amount of copper salt, reaction in feed water is quantitative after one hour. Some examples are given of successful application of this treatment in works of the I. G. Farbenindustrie A. G. in Merseburg and Ludwigshaven. Absorption of sulfur dioxide, which is conveniently taken from a container under constant pressure of 3 atmospheres, is more efficient with vertical flow of the hot water, since gas bubbles are thus better distributed and are gradually absorbed. Water pre-treated with caustic soda and soda

ash was treated at 65° with 40 p.p.m. excess of sulfite and was oxygen free on leaving feed water reservoir 1 to 2 hours later. In another case, water pretreated with caustic soda was dosed with sulfur dioxide at 38° to decrease the alkalinity and to remove oxygen, filtered through marble to guard against over-acidification and finally softened in a permutit filter. Combination of final de-aëration by sulfite with preliminary thermal de-aëration at 63° proved more economical than high vacuum de-aëration.—*Manz. Translated by Selma Gottlieb.*

Concerning the Treatment of Hot Water. L. W. HAASE. Ges.-Ing., **56:** 5, 49, February, 1933. In hot water, corrosion is due almost exclusively to oxygen; the calcium-carbonate-carbon-dioxide equilibrium influences only kind and amount of scale or sludge. Copper or copper-bearing alloys should be used in construction, since experience has shown that these materials are not attacked by tap water of normal composition. If use of resistant materials is not possible, as in old installations, suitable treatment must be used for removal of oxygen from water. Of proposed procedures, few have found use in practice. Pre-heating to 90 to 100°, with vigorous agitation to disengage gases, is possible only in small installations. Trickling de-aëration under various pressures, as used in boiler feed water treatment, is ruled out because of complexity of apparatus and its difficult operation. Addition of organic colloidal substances to form slimy protective coat on metal surface is of doubtful value, since solutions used discolor the water and increase its content of organic matter. Filters of metal turnings remove all oxygen at suitable rates of flow; but from iron turnings, divalent iron goes into solution, and from brass turnings, zinc. Solution of iron is accelerated if much carbon dioxide is present. To overcome this difficulty, previous de-acidification, or other treatment, is called for. For de-aëration of hot water, sulfite and bisulfite are used in practice, and are of sufficient stability. Hyposulfites are not favored because of their instability, in spite of their stronger and more rapid action. To prevent bad tastes from excess treatment, boiler temperatures should not be under 60°. If carbonate hardness is sufficiently high, addition of bisulfite changes the pH only a few tenths, yet enough to increase solution of iron appreciably. No corrosion was noted when alkaline sulfite was used.—*Manz. Translated by Selma Gottlieb.*

Comparative Bacteriological Investigations of the Efficacy of the Chlorine-Silver-Copper Method of Sterilization of Pool Waters. ADOLF BECK. Arch. f. Hyg. u. Bakt., **109:** 3, 177, December, 1932. The efficacy of chlorination and of combined procedures was investigated in a bathing establishment by determining the free chlorine, the bacterial count, and the coli titer. Chlorine-copper method gave best results and considerably lower bacterial count than chlorination alone. During chlorine-copper period, 11 out of 12 tests showed hygienically unobjectionable water, while, with chlorination alone, 6 samples from pool outlet showed more than 200 bacteria per cc. Chlorine-silver-copper method is somewhat better than chlorination alone; but chlorine-silver method gives poorer results than does chlorine alone. With equal chlorine dosages, chlorine-copper method gave highest chlorine residuals. With

chlorine-copper method, lower chlorine dosages give satisfactory sterilization. Silver seems to have an inhibitory effect. Experiments indicate that the bathing of one person without soap introduces from 1000 to 4000 bacteria into bathing water.—*Manz. Translated by Selma Gottlieb.*

The New Drinking Water System on the Rigi. CARL ZÜBLING. Ges.-Ing., **56**: 17, 199, April, 1933. The inhabitants of Rigi-Kaltbad, who had not previously had a hygienic drinking water supply, were furnished with a supply from the lower lying springs at Romiti. The water is collected at the pumping station into a 40,000 gallon reservoir, treated with sodium hypochlorite solution, and lifted by two electrically driven 8- and 9-stage turbine pumps, of 65 and 95 gallons per minute capacity respectively, 1066 to 1082 feet to the Grauhütte pumping station. This has two reservoirs of 53,000 gallons capacity each, from which Rigi-Kaltbad is supplied, and an electrically driven 9-stage pump working at 2900 r.p.m. and delivering 33 gallons per minute, which lifts the water a further 295 feet to the Hotel Edelweiss and surrounding houses. The plant is automatically operated by float valves. Emptying of the lower pumps at low spring water flows is prevented, the pumps being cut off automatically when danger level reached.—*Manz. Translated by Selma Gottlieb.*

Investigations of the Chemical Interaction between Bottom Sludge and Water. H. J. BANG. Ges.-Ing., **56**: 13, 150, April, 1933. Experiments on the influence of disturbance of bottom sludge on the quality of water showed no regularity; the findings were inconclusive and dependent on the compositions of sludge and of water, respectively, and on bacterial activity. Only the amount of dissolved organic matter increases regularly; but this stays within relatively narrow limits. When sludge is disturbed, dissolved organic matter plays a smaller part in the increased consumption of dissolved oxygen than does deposition of sludge particles. In tests in open water of the Havel, the rather high phosphate content of the water was considerably decreased when the sludge was disturbed.—*Manz. Translated by Selma Gottlieb.*

The Water Supply System of the City of Munich. Fortschritte der Technik, Beilage der Münchener Neuesten Nachrichten, January 18, 1933. To supplement two aqueducts dating from 1880–1890, leading from supply springs to the elevated reservoir, new aqueduct was built at a higher level, thus relieving the lower existing ones and supplying water at a higher level for higher sections of city. Conduit is of concrete, of 5.9 × 5.7 feet horse-shoe section, and was completed in 1932. Of the 15.6-mile length, 12 miles had to be tunneled through rock. New conduit discharges into new reservoir, with capacity of 1323 m.g. and located 101 feet higher than existing reservoir, for service to higher-lying districts. Pending completion of reservoir, by-pass connecting main with 124 feet high overflow tower discharge in neighborhood of existing reservoir has been constructed, by which excess water from new aqueduct is made available without affecting pressure in high-level system.—*Manz. Translated by Selma Gottlieb.*

A Comparison of MacConkey's Bile-Salt Broth and Dominick-Lauter Broth in Routine Water Analysis. T. N. S. RAGHAVACHARI and P. V. SITARAMA IYER. Indian J. Med. Research, April 1934. Advance copy. Literature relative to the occurrence of spurious positive presumptive *B. coli* tests and to use of DOMINICK-LAUTER medium (methylene-blue brom-cresol-purple broth) in water analysis is reviewed and results of series of comparative tests with latter medium and MACCONKEY'S lactose bile-salt neutral red broth (1.5 percent bile) on 72 samples of water from a variety of sources scattered over the whole of the Madras Presidency are given and discussed. Subcultures were made from the presumptive tubes on MACCONKEY'S neutral red bile-salt lactose agar and 6 colonies subjected to following tests: indole production, motility and Gram staining; methyl red and Voges-Proskauer reactions; citrate utilization; and fermentation of saccharose, dulcite, adonite, and inulin. Results are classified according to Standard Methods (A. P. H. A.), on basis of indole and methyl red tests, and on basis of indole and citrate tests. Authors have found this last the most reliable combination for differentiation of *B. coli* and *B. aërogenes*. The percentage of samples which yielded members of the colon-aërogenes group was 80.6 in case of MACCONKEY medium and 75 with DOMINICK-LAUTER medium, the percentages of presumptive positives confirming being 98.3 and 93.1, respectively. In addition, the MACCONKEY medium yielded a larger proportion of true *B. coli*, the percentages being 68.1 and 45.3, respectively, while the *B. aërogenes* percentages were 20.7 and 42.3, respectively. The remainder of the cultures were classified as intermediates. The MACCONKEY medium was also found to be more sensitive, yielding lactose fermenters on the average in smaller volumes of water. The standard method of the American Public Health Association is considered unsatisfactory in the following particulars: the use of lactose broth as the presumptive medium, the selection of only 2 colonies for confirmation, and the failure to differentiate between *B. coli* and *B. aërogenes*. MACCONKEY'S medium is considered the most satisfactory primary medium available for *B. coli* tests. Bibliography of 30 references.—*R. E. Thompson.*

Water Works Contracts. LEO T. PARKER. Water Works Eng., **86**: 25, 1245, December 13, 1933. Oral contract is usually enforceable, providing it does not relate to real estate sale, or extended leases, or is not particularly prohibited by law. Written contracts are governed by practically same laws. Numerous cases are cited where contracts entered into without complying with certain mandatory legal requirements have been declared void. When contract is ambiguous, complete testimony must be submitted to a jury to decide. Word "may" in contracts, state laws, city ordinances, and the like may be construed as meaning "must." Cases are cited which give private water companies, who are holders of municipal franchises, right to survey and condemn private property to obtain suitable supply. It is well established law that any state law, or city ordinance, whereby municipality is authorized to purchase a water works system, is void when such law fails to provide for collection of a tax for sinking fund to pay for purchase.—*Lewis V. Carpenter.*

All-Electric Pumping System. J. J. Garland. Water Works Eng., 86: 25, 1236, December 13, 1933. Peoria, Ill., water works company replaced steam pumps, which have all been in use since 1891, with electric-motor-driven centrifugal pumps. Old pumps weighed about 500 tons and it was necessary to pour five feet of concrete into the pump pit to prevent hydrostatic uplift. On test, new equipment showed average efficiency of over 86 percent.—*Lewis V. Carpenter.*

Copper Sulfate Treatment. J. K. Marquis. Water Works Eng., 86: 1284, December 27, 1933. Spartanburg, S. C., water works utilizes water from 1.25-billion-gallon reservoir for driving pumps to pump about one-tenth of domestic supply. Treatment of large reservoir with copper sulfate was found impracticable, so two barrels were rigged up for mixing copper sulfate solution and adding it through 10-cc. pipette under constant head in mixing chamber. Dosage varies from 0.2 to 1.6 p.p.m. Six hours detention period is provided. Number of algae present is usually very low, and they are getting 100-hour filter runs.—*Lewis V. Carpenter.*

Fort Wayne's New Water Plant. R. L. McNamee. Water Works Eng., 86: 1286, December 27, 1933. Project will ultimately consist of upper dam six miles distant, storing 700 m.g., and lower dam near city, storing 200 m.g. Water is used for hydro-electric power which is tied up with municipal lighting plant. Pumps are driven by two-speed motors, capacity of units varying from 4,000 to 22,000 g.p.m. as pond levels vary. Raw water is aërated through Sacramento type nozzles and then softened. Quick-lime is fed into primary mixing tanks, equipped with shaft paddle mechanisms, with detention period of 2 minutes. Slow motion paddle device is used during 45-minute flow through coagulation basin. Water then flows through clarifiers, followed by 4 hours of sedimentation. Carbon dioxide is generated in a coke producer and is added through diffuser piping. From carbonation tanks, water flows to ten 2.4-m.g.d. filters. Structures are supported on about 8,000 piles which were designed for uplift on account of high water. Effort was made to concentrate plant over small area, which resulted in two-story settling tanks. The aërators constitute a third story.—*Lewis V. Carpenter.*

Operation and Construction of a Simple Chemical Dosage Chart. Everett C. Handorf. Water Works Eng., 87: 1, 25, January 10, 1934. Alignment chart for computing the chemical dosage consists of three logarithmic scales, center one of which is straight line conversion scale for grains per gallon to parts per million, while upon the other two are read the varying quantities of water and the required dosage. Method of reproduction of chart is explained in detail.—*Lewis V. Carpenter.*

Overhauling Rapid Sand Filters. August G. Nolte and Warren A. Kramer. Southwest Water Works Jour., 15: 1, 9–12, 1933. Unexpected overhauling of filters has been necessary due to blocking of passages by foreign matter, careless handling of cement, improper placement of gravel, non-alignment, faulty design, and incrustation on sand grains and strainers. Methods of

inspection, for cleaning sand bed, for partial and complete overhauling, and for screening and replacing gravel and sand are discussed.—*O. M. Smith (Courtesy Chem. Abst.).*

Overhauling Filters at the Chain of Rocks Plant, St. Louis, Mo. August G. Nolte and Warren A. Kramer. Southwest Water Works Jour., 15: 2, 7-9, 1933. Mud ball troubles were eliminated by increasing rate of wash from 12 to 24 inch vertical rise per minute. Clogging of strainers by zinc oxide coating, originating from corrosion of Tobin bronze plates, increased water pressure in washing, and much trouble resulted from bolts and strainer plates breaking. Increasing size of strainer openings from $\frac{1}{16}$ to $\frac{3}{32}$ inch increased rate of washing from 24 to 36.5 inches vertical rise per minute and eliminated mud balls and broken plates.—*O. M. Smith (Courtesy Chem. Abst.).*

Water Main Installation and Maintenance. W. H. Waring. Southwest Water Works Jour., 15: 3, 13-15, 1933. Methods used at Dallas, Texas.—*O. M. Smith.*

Dominick-Lauter Medium Compared with Standard Lactose Broth for B. Coli Determination. H. V. Stewart. Southwest Water Works Jour., 15: 1, 19-20, 1933. Cf. C.A., 25: 1307. This medium did not show gas formation in presence of any gas-forming organisms, excepting *B. coli.*—*O. M. Smith (Courtesy Chem. Abst.).*

Control of the Chemical Treatment of Water. Marvin C. Nichols. Southwest Water Works Jour., 15: 3, 7-9, 1933. Résumé of water treatment.—*O. M. Smith (Courtesy Chem. Abst.).*

Geology of Arbuckle Mountains as to Water Supply. Chas. E. Decker. Southwest Water Works Journal, 16: 2, 9, May 1934. Discussion of geological structures and water resources of Arbuckle Mountains area in south central section of Oklahoma. *J. H. O'Neill.*

Study of the Water Resources of Arkansas. John H. Gardiner. Southwest Water Works Journal, 16: 2, 13, May 1934. Description of work of U. S. Geological Survey in studying water resources, and of its application to Arkansas.—*J. H. O'Neill.*

Clay Used as Artificial Turbidity to Eliminate Short Filter Runs. Carl Leipold. Water Works and Sewerage, 80: 8, 304-5, August 1933. Clay secured by crushing "green" bricks was applied to mixing basin at rates varying from 1.1 to 7.1 g.p.g. It was found that for satisfactory operation with artificial turbidity, mixing period must exceed 15 minutes and coagulation period must be greater than 2 hours. Periods less than these caused mud balls and cracking in filters. Too rapid settling of clay caused difficulties in cleaning mixing basin.—*C. C. Ruchhoft.*

The Bacterial Efficiency of the Excess-Lime Method of Water Purification. H. W. Streeter. Public Works, 64: 8, 17–9, August 1933. Experiments were conducted over period of nine months at Cincinnati experimental filter plant by dividing raw water into two equal sections and adding lime to one. Dosage varied from that sufficient to produce basicity, but no causticity, up to causticity of 70 p.p.m. Results showed marked bactericidal effect which varied directly with the intensity of treatment. Excess lime diminished bacterial efficiency of post-chlorination. Considered as method of disinfection, excess-lime treatment is more difficult to control and less consistent than ordinary chlorination.—*C. C. Ruchhoft.*

Organic Iron and Color Removal Facilitated by Use of Permanganate. Thomas R. McCrea. Water Works and Sewerage, 80: 6, 225–6. June 1933. Elizabeth City, N. C., secures from Dismal Swamp lands a supply varying in color content from 150 to 550 p.p.m. Previous treatment included chlorinated-copperas followed by alum and lime. Following period of severe drought, color increased to 900 p.p.m. and a considerable quantity of soluble, organically bound iron made its appearance. Laboratory experiments indicated following plant procedure, which eliminated all difficulties: lime was added at influent end of mixing chamber, sufficient to produce a pH of 8.8 to 9.8: this was followed by 0.25 g.p.g. of potassium permanganate which preceded usual dose of chlorinated-copperas. It was found possible to apply a second dose of lime to filter effluent and produce a final pH of 6.8 to 7.4 without return of color.—*C. C. Ruchhoft.*

Problems Involved in Providing Safe and Adequate Water Supplies for Oil Refinery Uses. Sheppard T. Powell. Water Works and Sewerage, 80: 6, 211–15, June 1933. Uses of water in this type of plant may be classified as follows: cooling water for condenser, boiler feed water, fire protection, and sanitary supply. First two classifications require non-corrosive source, which is usually secured by one of the several softening methods. Control of corrosion, scale formation, and embrittlement is accomplished by maintaining pH of 9.0 or higher, complete deaeration, and correct ratio of sulfate to amount of sodium carbonate or caustic soda present. In using contaminated source for fire protection, great care should be exercised to prevent cross-connections with sanitary supply.—*C. C. Ruchhoft.*

Water Purification Studies. H. W. Streeter. Public Works, 64: 6, 12–14, June 1933. Data from experimental water purification plant at Cincinnati have provided following facts. Using 37°C. total count as index, efficiency of filtration is higher in winter than in summer, while reverse is true of chlorination. Using same index, over-all efficiency of removal is directly affected by variations in raw water turbidity. Variations in temperature, or in turbidity, showed little effect upon *B. coli* removal. Data from ten Ohio River plants indicated a general relationship between yearly mean and frequency with which bacterial counts equaled, or exceeded, various amounts. Thus increase in mean river pollution results in increase in frequency of lapses below a given count. Excess-lime treatment is not as advantageous as prechlorination.

Prolonged storage, when possible, effects desirable improvement in bacterial and physical qualities of highly polluted sources. Purification efficiency is definitely limited, according to law of diminishing returns, as degree of raw water pollution increases.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Iron Removal and Zeolite Softening Plant at Lancaster, Ohio. CHARLES P. HOOVER. Public Works, **64:** 6, 9–11, June 1933. Present capacity of 2 m.g.d. can be easily increased to 3 m.g.d. Supply is taken from two 8-inch wells which discharge into inlet of Aero-Mix unit. This is followed by 30-minute detention in reaction basin, with resultant removal of 50 percent of carbon dioxide and oxidization and precipitation of from 2.4 to 3.4 p.p.m. of iron present. After filtration through sand beds of conventional size and composition the water is pumped up through beds of Crystalite. Provision is made for automatic proportioning of hard and soft water. Zeolite runs have averaged 8.4 hours, with removal capacity of 12,000 grains per cubic foot. Salt consumption has been one-third pound per 1000 grains of hardness removed, while water required for regeneration has averaged 3.9 per cent of total pumpage. Salt cost for reducing hardness from 359 to 76 p.p.m. has averaged 2.25 cents per 1000 gallons.—*C. C. Ruchhoft.*

Present Status of Water Softening. Anon. Public Works, **64:** 6, 17–8, June 1933. Comparisons between the lime-soda-ash and zeolite methods indicate that the preference will depend upon the nature and composition of the supply. For turbid waters containing quantities of sodium salts, iron, or manganese, lime method is preferable. Other factors include disposal of sludge and amount of water available.—*C. C. Ruchhoft.*

Interesting Experiences in Locating Pipe Lines. ROGER W. ESTY. Water Works and Sewerage, **80:** 9, 323–6, September 1933. Application of the wireless pipe locator saves its cost many times by accurately and quickly providing this valuable information.—*C. C. Ruchhoft.*

Obstacles Encountered in the Flow of Water Through Filter Beds. JOHN R. BAYLIS. Water Works and Sewerage, **80:** 9, 335–6. September 1933. Filter preformance is largely influenced by following factors: size of openings in filtering material, amount and characteristics of suspended material, and extension of filtering surface by cracks and by pulling away from side walls. First factor may be expressed mathematically, but as yet this cannot be done with the second factor. The third may be alleviated by some method of surface washing. These suggestions indicate the difficulties encountered in attempting to express filter performance by means of a mathematical formula. —*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Water Coagulation with Ferric Chloride. ROBERT NEWTON CLARK. Public Works, **80:** 7, 22, July 1933. Comparative tests on ferric chloride and alum indicate a decided advantage for the former. Results indicate that a similar reduction in turbidity may be obtained, on average, with 55 percent less of ferric chloride than of alum. Time of floc formation is shortened, thus render-

ing smaller sedimentation basins possible. Coagulation is effective at any pH above 5.0, in comparison with limited pH range of alum precipitation. Overdosing does not affect filter efficiency and in case of soft, colored waters, ferric chloride removes more color than does alum.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

New Six Million Gallon Storage Tank. HERBERT H. BROWN. Water Works and Sewerage, 80: 7, 237–40, July 1933. In order to maintain pressure in outlying districts of Milwaukee, Wis., it was decided to provide booster pumping station with sufficient storage capacity at low elevation to supply pumping equipment. First tank is of ground storage type, completely arc-welded in field. With diameter of 165 feet and height of 37.5 feet, steel plates vary in thickness from $1\frac{3}{16}$ inch at bottom to $\frac{3}{8}$ inch at top. Conical roof, supported by steel trusses, is of $\frac{3}{16}$-inch copper-bearing plate. Total weight is about 660 tons and contract price was guaranteed not to exceed $89,500.—*C. C. Ruchhoft.*

Water Department Autonomy Permits Sound Fiscal Policy. OTTO ECKERT. Eng. News-Rec., 108: 617–8, April 28, 1932. Water system of Lansing, Michigan, is controlled by independent water and light board, which permits operation on strictly business principles. The 8 members of board, 2 being appointed by mayor each year for 4-year term, serve without remuneration. Board appoints secretary and general manager to whom all other employees are responsible. Chief-of-plants and superintendent of distribution report directly to general manager. City charter provides that all funds collected shall be used to meet liabilities incurred by board, and shall not be withdrawn, or used for any other purpose whatsoever. Board has full authority to fix all rates. All services are metered. Per capita consumption is 112 gallons per day. Average residence bill is less than $1.10 per month. Rates are sufficient to take care of reasonable growth without bond issues. Water mains are installed without charge to adjacent property only when customer is ready to take water from each 100 feet of main installed. In new real estate developments, cost must be advanced by developers, and is repaid when revenue amounts to 10 percent of cost. City pays for all water used for general city purposes, which is mostly metered, at rate slightly lower than that for largest industrial consumers, namely, $5\frac{1}{4}$ cents per 100 cubic feet, and additional $53,000 annually for fire protection. Latter amount is equivalent to $45 per hydrant and is about 20 percent less than actual cost of furnishing fire protection service, including depreciation and interest. No charge has yet been made for private fire services and automatic sprinkler installations. Water department does not pay taxes. Collections are very good, discount of 20 percent being allowed for prompt payment. Uncollectable accounts have amounted to less than 0.2 percent of total billing during last 10 years. Record of each customer's account is kept on individual loose-leaf ledger sheet. By means of communicating system and pneumatic tube, customer's ledger sheet, covering from 3 to 12 years, can be laid before him at counter on first floor of office building in less than 2 minutes. Operating costs are carefully analyzed and compared on both total and unit basis with cost for same month of previous year, fiscal year to date, and 12 months just past with previous 12 months. Some 72

items are so compared. In order to plan capital expenditures intelligently, thorough survey is made every 2 years of all factors that might influence future of department, recommendations for additions during next 2 years being made and any large expenditure that might have to be met in not too far distant future pointed out. In 47 years of operation there have been only 2 periods when money was borrowed. Bonds now outstanding amount to $1,210,000, and fixed capital of department, less depreciation, totals more than $3,000,000. All bond retirement and interest payments have been made when due from revenue.—*R. E. Thompson.*

Economic Factors in Water-Main Reinforcement. Paul Hansen. Eng. News-Rec., 108: 618–9, April 28, 1932. Discussion of factors affecting economic design of reinforcements to distribution systems. There is always a limit to water demand which may be met. It is unwise to restrict consumption by merely permitting pressure to drop. This is inequitable, consumers near source having distinct advantage. Moreover, dropping pressure is dangerous, as it may result in pollution entering mains through siphonage from plumbing fixtures, or through defective joints. Restriction of size of service connections is always unpopular. Most equitable method and probably easiest to enforce is ready-to-serve charge based on size of service connection. Generally, it is desirable, in interest of economy, to lay large mains to form closed circuits. Distribution systems of Lake Forest and Wilmette, Illinois, are described briefly as examples of extreme variations in distribution system requirements in different communities. Former is made up chiefly of large estates, and maximum hourly rate of consumption is as high as 960 gallons per capita daily, average consumption being 240 gallons per capita per day. In Wilmette, average daily consumption is 93 gallons per capita and maximum hourly rate 236 gallons per capita per day.—*R. E. Thompson.*

Notes on Water Softening Plant. J. C. Cotterill. Gas J., 197: 205–8; Gas World, 96: 2477, 78–81, 1932. From Chem. Abst., 26: 2536, May 10, 1932.—*R. E. Thompson.*

Research Aids Economy in Filter Plant Design. Arthur B. Morrill. Eng. News-Rec., 108: 622–5, April 28, 1932. Description and discussion of experimental studies made in connection with design of new 280-m.g.d. Springwells filtration plant in Detroit. Real purpose of rapid sand filtration is to remove turbidity, bacterial removal being incidental: bacteria, when turbidity is absent, can always be eliminated much more cheaply and quite as surely by chlorination. Prime purpose of coagulation, or sedimentation, basins is to reduce load on filters and increase their capacity for delivering water free from turbidity. Probably satisfactory water could be produced in many cases without preliminary sedimentation, just as coagulation and long sedimentation would produce satisfactory water without filtration. Neither process alone would be as economical as proper combination of the two. Problem is to find what combination of capacities will result in lowest total cost, considering both fixed and operating discharges.

Economics of Deep-Well Pumping Equipment. F. G. Gordon. Eng. News-Rec., **108:** 620–1, April 28, 1932. Selection of pumping equipment for deep-well installations is discussed. In general, it may be said that under conditions suitable for use of any of 3 types, air lift, plunger, and turbine, trend is apparently toward use of latter. Graph is given showing difference in power costs over period of 1 year for pumps of different efficiencies operating at 1-m.g.d. rate, and, to permit ready interpolation between efficiencies shown for more and less efficient pumps, second diagram is included showing difference in pumping costs for fixed head conditions and fixed rate for power. Latter curve shows that reduction in a high efficiency is not as serious as reduction in a low efficiency. For example, with 100-foot lift and power at 1 cent per kilowatt-hour, reduction in overall efficiency from 60 to 40 per cent increases cost of pumping at 1-m.g.d. rate $950 per year, while reduction from 30 to 20 percent efficiency increases cost $1910. It is apparent, therefore, that pumping equipment with low over-all efficiency should be kept at peak of efficiency at all times. Efficiency tests should be regularly conducted, and when lower efficiency is observed, reason should be determined and fault corrected.—*R. E. Thompson.*

The Manometric Delivery-Head of Centrifugal Pumps. H. Kissinger. Chem. Fabrik, 1932, 65–7. From Chem. Abst., **26:** 2350, May 10, 1932. Analysis and explanation of usual data on pump operation given in manufacturers' catalogs.—*R. E. Thompson.*

Reducing Water Cost While Improving Quality. Harry N. Jenks. Eng. News-Rec., **108:** 626–8, April 28, 1932. Sacramento has owned and operated its water works since 1853. Rapid sand filtration was introduced in 1924. Summary of analyses of raw and treated water in 1931 is given. Major problem is taste removal during summer season. New pre-treatment works are under construction and specific taste and odor removal process will be adopted. It is also planned to adjust pH with lime for corrosion prevention. Average total hardness of tap water is 83 p.p.m., an almost ideal figure. There is wide variation in hardness, however, from 198 to 18 p.p.m. Turbidity of tap water seldom exceeds 0.1 p.p.m., *B. coli* index has at all times been zero in 50 cc., and total bacterial count has consistently averaged less than 2 per cc. Program of water waste prevention through metering and of equitable adjustment of water charges is being initiated. Average consumption is about 270 gallons per capita daily. New works will increase plant capacity to 64 million gallons per day. Total cost of water delivered to consumer, 7.5 cents per 1000 gallons, including pumping, filtration, and distribution, is among lowest on Pacific Coast. Despite good results, status of filtration has been subject of considerable controversy, owing to advocacy of mountain source of supply known as Silver Creek project. It is possible that mountain water will become ultimate source of supply. City organization chart is included showing position occupied by water division in city administrative affairs.—*R. E. Thompson.*

Saving Pumping Costs by Pressure Adjustment. Myron B. Reynolds. Eng. News-Rec., **108:** 628–9, April 28, 1932. By reducing unnecessary pump-

ing station pressures, Chicago has been able to effect saving of $80 per day in power costs at the five North Side stations. Constant pressure of 25 pounds at remotest point in distribution system is governing factor in operating schedule recently put into practice. City is prepared to furnish water at rate of more than 400 gallons per capita daily, which more than meets demand except during extremely hot weather. Studies are being continued.—*R. E. Thompson.*

Results of Tests on Siphon Spillways for Large Flume. T. J. Corwin and A. W. Kidder. Eng. News-Rec., **108**: 649–52, May 5, 1932. Siphon spillways were selected to discharge excess flows in Tiger Creek conduit of Mokelumne River power development of Pacific Gas and Electric Co., on basis of reliability, close regulation of water-surface elevation, low cost, and freedom from maintenance. Seven siphons were installed at points where feeders enter the 20-mile conduit, and tests were made on four to check performance and effect possible improvements in design. Test procedure and resulting modification in design and efficiency are described.—*R. E. Thompson.*

Research in Hydrology to be Undertaken by Nine Committees. Eng. News-Rec., **108**: 663, May 5, 1932. Research into all major phenomena bearing upon hydrology is to be undertaken by 9 permanent committees recently named by section on hydrology of American Geophysical Union, according to announcement of National Research Council, Washington, D. C.—*R. E. Thompson.*

Location and Study of Pipe-Line Corrosion by Surface Electrical Measurements. C. Schlumberger, M. Schlumberger and E. G. Leonardon. Am. Inst. Mining Met. Engrs., Tech. Pub. No. 476, 24 pp., 1932. From Chem. Abst., **26**: 2404, May 10, 1932. Geophysical methods are described which detect both autogalvanic corrosion and electrolysis by stray currents.—*R. E. Thompson.*

Dimethyl-p-phenylenediamine Hydrochloride for the Determination of Small Quantities of Chlorine. Knut Alfthan. Finska Kemistsanfundets Medd., **36**: 109–12, 1927. From Chem. Abst. **25**: 2071, May 10, 1931. Reagent gives with chlorine same color shade as acid solution of methyl red. Water is treated with reagent and resulting color is compared with those of known strength of methyl red. Sensitivity is 0.01 milligram.—*R. E. Thompson.*

A New Reagent for Fluorides. Camillo Pertusi. Atti III congresso naz. chim. pura applicata 1930, 573–5. From Chem. Abst., **25**: 2076, May 10, 1931. Reagent consists of solution of benzidine acetate, prepared from 1.84 grams benzidine, a little concentrated acetic acid and distilled water to make up to 500 cc., and 0.02 normal mercury succinimide solution, mixed in equal parts. Reaction is quite evident with drop of 0.05 normal alkali fluoride or 0.00004 gram of hydrofluoric acid. Precipitate is a complex containing 2 molecules of benzidine dihydrofluoride to 1 molecule of mercuric fluoride.—*R. E. Thompson.*

Evolution of Hydrogen Sulfide in the Bay of Krasnovodsk. D. Zabriev. Azerbaĭdzhanskoe Neftyanoe Khozyaĭstvo, 1930, 10, 58–63. Chem. Abst., 25: 2031, May 10, 1931. Rôle played by microörganisms is described.—*R. E. Thompson.*

Cast Iron: Methods of Testing. E. Dübi. First Communications New Intern. Assoc. for Testing Materials A, 10–24, 1930. From Chem. Abst., 25: 2093, May 10, 1931. Separate cast piece of 50 mm. diameter gives results which agree very closely with those obtained from test pieces of 30 and 50 mm. diameter machined from main casting. Small test pieces taken according to French specifications from main casting give valuable criteria of nature and uniformity of internal structure of casting itself. As regards strength of material, however, these small test pieces do not give any more accurate indications than specially cast pieces having diameter corresponding as nearly as possible to thickness of wall of casting under investigation. Strength properties of casting can apparently be determined conclusively only from tests on casting itself.—*R. E. Thompson.*

Cast-Iron Testing in Great Britain. J. G. Pearce. First Communications New Intern. Assoc. for Testing of Materials A, 1–4, 1930. From Chem. Abst., 25: 2094, May 10, 1931. Specification which has approval of founding industry was issued in 1928 by British Engineering Standards Association. While it covers only 2 qualities of iron for general engineering castings, testing procedure is applicable to all types and qualities. Features are as follow. Size of test bar varies with thickness of casting, 3 sizes being used at present. Test bars are cylindrical and may be cast away from casting. Both tensile and transverse tests are covered and no chemical analysis is demanded. Majority of engineering castings will be covered by intermediate size of bar, 1.2 inches in diameter, which is virtually standard bar used on Continent and in America. Adoption of this basis for testing has stimulated considerable amount of investigation on relations between mechanical properties, but it is believed that at present stage of development no other mechanical tests can be usefully employed in general specifications.—*R. E. Thompson.*

Heat Treating Pipe-Line Couplings. C. B. Phillips. Steel, 87: 26, 43–5, 1930. From Chem. Abst., 25: 2090, May 10, 1931. A Plant of Dresser Manufacturing Company at Bradford, Pennsylvania, is described.—*R. E. Thompson.*

Corrosion of Steel Water Pipes by Stray Electric Currents. Otto Rothe. Rev. brasil. chim., 2: 249–54, 1930. From Chem. Abst., 25: 2103, May 10, 1931. After period of 1 or 2 years, pipes showed holes which from appearance and from presence of ferric chloride at places not yet perforated made deduction reasonable that damage was caused by continuous electric current. Author tested pipes at various points of city and found that they were possibly charged in relation to soil around them; potential density from voltage of trolley car power lines had maximum of 10 volts. Funnel-shaped holes filled with ferric chloride, similar to those in city water pipes, were produced in

laboratory. Perforations occur where asphalt protection is damaged and electric current permitted to pass.—*R. E. Thompson.*

Sterilization of Drinking Waters at Saïgon and at Cholon. J. Guillerm. Arch. inst. Pasteur Indochine, 1929: 10, 36–55; Chimie & industrie, 25: 69, 1931. From Chem. Abst., 25: 2216, May 10, 1931. The water, which is obtained from underground stratum imperfectly protected from contamination by overlying layer of clay of varying thickness and insufficient impermeability, is rendered perfectly safe by chlorination with bleaching powder at cost of 0.0008 franc per cubic meter.—*R. E. Thompson.*

Subsoil Management, Particularly from the Viewpoint of Water Mains. Brabant, Moyaerts, et al. L'eau 24: 1, 5–8, 1931. From Chem. Abst., 25: 2218, May 10, 1931.—*R. E. Thompson.*

Lead Poisoning from Drinking Water in Leipzig. Kruse and M. Fischer. Deut. med. Wochschr., 56: 1814–8, 1930. From Chem. Abst., 25: 2219, May 10, 1931. Clinical account of recent epidemic.—*R. E. Thompson.*

Detection of Bromides by the Drop Method. A. V. Pavlinova. Ukrainskii Khem. Zhurnal, 5: Sci. Pt., 231 (German Abstract 232), 1930. From Chem. Abst., 25: 2076, May 10, 1931. Method is based on fact that pernitric acid, formed by interaction of hydrogen peroxide and nitrous acid, liberates bromine from bromides. Bromine gives pink eosin color with fluorescein. Reaction is sensitive to 1:12,500. Chlorides do not interfere; iodides do, but can be removed with sodium thiosulfate.—*R. E. Thompson.*

Titrimetric Determination of Small Quantities of Ammonia, with Particular Attention to Water Analysis. S. Kühnel Hagen. Z. anal. Chem., 83: 164–75, 1931. From Chem. Abst., 25: 2074, May 10, 1931. Apparatus is shown which is suitable for determination of free ammonia. One principal advantage lies in avoidance of rubber stoppers and connectors and in use of quartz condenser tube. Ammonia is caught in measured volume of N/140 hydrochloric acid and excess titrated with sodium hydroxide of same strength, using as indicator 0.01 per cent solution of methyl red and 0.04 per cent solution of bromothymol blue in 96 per cent alcohol. For determination of total organic nitrogen it is recommended to heat with sulfuric acid, 0.1 gram graphite, 0.75 gram mercuric sulfate, 1 gram copper sulfate (pentahydrate), and some potassium sulfate, and distil as usual after adding sodium sulfide and sodium hydroxide. With apparatus and method described, from 0.1 to 0.3 milligram ammonia may be determined with accuracy of about 5 per cent.—*R. E. Thompson.*

Boiler-Scale Prevention by the Use of Trisodium Phosphate in Modern Boiler Management. Paul Koeppel. Chem.-Ztg., 55: 58–9, 1931. From Chem. Abst., 25: 2219, May 10, 1931. Sodium phosphate is ideal softener for modern high-pressure boilers. It is inexpensive and efficient and requires no special feed equipment. Contact during only 1 hour at 70° is required to precipitate calcium and magnesium salts.—*R. E. Thompson.*

Water Purification for Color Removal. A. S. Behrman, R. H. Kean and H. Gustafson. Paper Trade J., 92: 8, 121–3, 1931. From Chem. Abst., 25: 2217, May 10, 1931. Modern methods of color removal are briefly reviewed, and some account is given of investigation into nature of coloring matter in water and of new methods of removal based thereon. It was found that: (1) particles of coloring matter are negatively charged; (2) they are chiefly colloidal, though grading down in some cases to molecular dimensions (true solution); (3) coloring matter in surface waters is essentially organic; (4) in many cases color deepens considerably with increase in pH of water, particularly in pH region near 7; (5) color is destroyed to considerable, but variable, extent by chlorination. Excess chlorine must be removed after destruction of color in order to prevent corrosion. With all waters tested, it was found that dechlorination by filtration through granular Hydrodarco removed not only residual chlorine, but also all residual color. Filtration through Hydrodarco, without previous chlorination, removed all, or nearly all, color; but, owing to costliness of revivification, it is usually more economical to remove as much color as possible by coagulation and filtration under carefully controlled pH conditions, followed by chlorination and then, if necessary, dechlorination. Attempt is being made to find method of revivification sufficiently simple to make it practical and economical to decolorize directly with Hydrodarco, without preliminary coagulation, filtration, or chlorination.—*R. E. Thompson.*

Method of Determination of the Chlorine Demand of Any Water. D. K. Pattillo and F. D. West. Paper Mill 54: 5, 4, 1931. From Chem. Abst., 25: 2218, May 10, 1931. Method consists essentially in titrating 500 cc. of sample with hypochlorite solution containing 0.0001 gram available chlorine per cc. until blue color is obtained with iodized starch solution used as outside indicator, adding further slight excess of chlorine, and then determining residual.—*R. E. Thompson.*

Galvanized Iron Pipes for City Water Supply. J. De Graaff. Verslag. Mededeel. betreffende Volksgezondheid, July, 1930, 8 pp. From Chem. Abst., 25: 2218, May 10, 1931. Galvanized iron piping should be non-porous. To test for porosity of zinc coating, pour 10 per cent gelatin solution containing 1 per cent potassium ferricyanide on inside of pipe cut longitudinally in half. After 24 hours at room temperature, blue spots in solidified gelatin indicate breaks in coating. Thickness of zinc layer should be sufficient. It is determined by measuring hydrogen evolved when zinc from measured area is dissolved in hydrochloric acid (density 1.2) to which 20 grams antimony trioxide per liter has been added. This acid does not attack iron. Simple apparatus for determination is described: one end of copper tube, 3 cm. long and 2 or 3 cm. in diameter is filed off to fit, standing vertically upon, inside galvanized pipe cut longitudinally in half. Proper sealing is effected by pouring asphalt around copper pipe. Acid is poured in through funnel in one hole of double-bore stopper closing copper pipe; hydrogen evolved escapes through other hole and is collected and measured in bottle. Minimum of 600 grams zinc per square meter of galvanized surface (one side) is required. Lead content of zinc used should be less than 0.5 per cent. Whether zinc will be

effective in reducing corrosion, depends upon nature of water. If calcium carbonate deposit forms, corrosion will be negligible; if not, the zinc will in time dissolve and corrosion take its course. Water of low hardness will contain as much as 3.9 p.p.m. zinc after standing 1 night in galvanized piping. Water standing in new pipe for 36 hours contained as much as 7 p.p.m. Zinc gives at best temporary protection.—*R. E. Thompson.*

Metal Corrosion. G. CHAUDRON. La Nature, 1930, I, 172–4; Wasser u. Abwasser, **27**: 171. From Chem. Abst., **25**: 2404, May 20, 1931. Electrochemical theory of corrosion and influence of oxygen discussed. Corrosion is best determined by exposure under fixed conditions of temperature, etc., and weighing. Protective alloys and coatings are also discussed.—*R. E. Thompson.*

Deterioration of Concrete in Hydraulic Structures. A. EKWALL. First Communications New Intern. Assoc. for Testing of Materials **B**, 162–6, 1930; cf. C. A., **23**: 5558. From Chem. Abst., **25**: 2262, May 10, 1931. Inspections of hydraulic structures in Sweden 10 years ago showed some defects in concrete and continued observations proved that concrete in some cases was subject to increasing deterioration. Investigations showed that deterioration occurred only in structures exposed on one side to water and was caused by solubility of lime and decomposition of other chemical combinations in hydrated cement. Particular attention was therefore directed to solubility of cement and aggressiveness of water. Practical experiments were made at same time with concrete slabs exposed to low water pressure during several years. It was proved that Swedish waters need not be considered aggressive in this respect. Importance of using sand relatively free from organic substances was impressively established. Leaner mixtures than 1:4.5 should not be used for concrete exposed to water pressure from one side. Admixture with cement of 10 per cent lime, or 5 per cent calcium chloride, improved watertightness; while 25 per cent trass, or slate powder, gave practically no improvement.—*R. E. Thompson.*

Resistance of Concrete Pipes to Corrosion by Water. J. O. ROOS. First Communications New Intern. Assoc. for Testing of Materials **B**, 144–8, 1930. From Chem. Abst., **25**: 2261, May 10, 1931. In Sweden, deterioration of concrete pipes is due mostly to external action of water percolating through pipe wall and extracting lime from cement. Pure water has high disintegrating effect; water containing from 0.30 to 80 p.p.m. of carbon dioxide increases, and lime hardness decreases, corrosion. To be durable, concrete pipes must be impermeable to water.—*R. E. Thompson.*

Treatment of Water for Ice Manufacture. DANA BURKS, Jr. Univ. Ill. Eng. Expt. Sta., Bull. **219**, 114 pp., 1930. From Chem. Abst., **25**: 2218, May 10, 1931. Neutralization with alum, or sulfuric acid, to convert carbonates to less troublesome sulfates and ample and effective air agitation in specially designed ice can produced marketable ice, fairly free from opaque zones. If, however, core water reaches critical concentration of salts, it must be replaced with new supply. Second line of attack involved utilization of exchange prop-

erties of magnesium zeolite to replace sodium salts in water with corresponding magnesium compounds. Subsequent liming, followed by alum and acid treatment, rendered water, which originally contained sodium bicarbonate, satisfactory for ice manufacture.—*R. E. Thompson.*

Water Supply for High-Pressure Boilers. Charles R. Hazen. Pulp Paper Mag. Can., 31: 195–8, 1931. From Chem. Abst., 25: 2219, May 10, 1931. Formation and effects of scale and factors favoring corrosion are briefly reviewed, and usual softening methods are outlined. Latter do not furnish water suitable for very exacting requirements of high-pressure boilers. Prime essential is clean evaporating surfaces; this can be obtained by properly controlled addition of sodium dihydrogen phosphate, either in boiler or before feeding, with, or without, preliminary softening treatment, according to nature of raw water.—*R. E. Thompson.*

Experiments and Results with Boiler-Water Re-cycling. Feige and Weiss. Arch. Wärmewirt., 12: 16–8, 1931. From Chem. Abst., 25: 2501, May 20, 1931. Rather full account is given of practical experiments on 1000-h.p. boiler, returning blow-down to feed water continuously through 3-mm. orifice. No difficulty was experienced, and indicated saving was 1500 marks per year.—*R. E. Thompson.*

The Solution Velocity of Oxygen in Water. IV. Susumu Miyamoto and Akira Nakata. Bull. Chem. Soc. Japan, 6: 9–22, 1931; cf. C. A., 25: 635. From Chem. Abst., 25: 2354, May 20, 1931. Oxygen gas was passed into sodium sulfite solution while stirring. Rate of oxidation was independent of concentration and dependent only on surface area exposed and temperature. Rate of stirring was constant and only pure oxygen was used. Theory is proposed that only those molecules of oxygen dissolve whose component velocity normal to surface is greater than threshold value about 3.4 times the root mean square velocity.—*R. E. Thompson.*

Outline of Welding and Allied Processes. F. T. Llewellyn. Metal Progress, 18: 6, 95–104, 19: 1, 51–60, 1931. From Chem. Abst., 25: 2405, May 20, 1931. Outline of practice recommended by committee of American Society for Steel Treating.—*R. E. Thompson.*

Theory of the Rust-Protective Action of Protective Coatings. W. Beck. Korrosion u. Metallschutz, 6: 229–30, 1930; Gas J., 193: 216–7, 1931. From Chem. Abst., 25: 2403, May 20, 1931. Mechanism of protective action of coatings discussed. Explanation is given of why, in spite of very distinct lack of electrical insulation, effective rust protection may exist. Adsorption layers may be formed on surface of metal which may have great protective value and yet, on account of their great thinness, only very low electrical resistance. Impossibility is emphasized of drawing conclusions from poor insulating qualities of protective coating as to its protective value.—*R. E. Thompson.*

First Report of the Corrosion of Pipes Sub-Committee. Albert Stokes, et al. Inst. Gas. Eng., 1930, Communication 20, 10 pp. From Chem. Abst., 25:

2404, May 20, 1931. Effects of various coatings on wrought iron and steel were determined by 2 types of tests: (*a*) coated metal was placed in soil and made anode of closed electrical system, source of current being 6-volt battery: current was measured at intervals and resistance of coating calculated; (**b**) e.m.f. differences between coated and uncoated specimen were measured. Resistance of coating decreased with increasing water content, while e.m.f. values increased. Painted pipes showed much greater resistance than bare pipe. Pipes covered with paper wrappings and painted were about 50 times as resistant as those with paint coatings only. Deep pits occurred in metal surfaces where coatings were broken. Cement coatings were found temporarily resistant to stray current electrolysis. Also in Gas J., 192: 725–9, 1930.—*R. E. Thompson.*

The Algae Flora of the Ruhr River. HERMANN BUDDE. Arch. Hydrobiol., 21: 559–648, 1930. From Chem. Abst., **25**: 2459, May 20, 1931. Numerous data on composition of Ruhr water are included. Analyses comprised temperature, transparency, color, sediment, reaction, pH, hardness, bacteria, organic matter, chloride, nitrate, nitrite, ammonia, iron, carbon dioxide, and oxygen. Extensive bibliography.—*R. E. Thompson.*

Organic Matter Given Off by Algae. AUGUST KROGH, EUGEN and WILLIE SMITH. Biochem. J., **24**: 1666–71, 1930. From Chem. Abst., **25**: 2456, May 20, 1931. Culture experiments show that organic material synthesized by assimilation of freshwater algae remains almost quantitatively stored in cell.—*R. E. Thompson.*

Present Status of the Investigation of the Cause, and of the Geographical Distribution, of Mottled Enamel, Including a Complete Bibliography of Mottled Enamel. FREDERICK S. MCKAY. J. Dental Research, **10**: 561–8, 1930. From Chem. Abst., **25**: 2476, May 20, 1931. Evidence has been so overwhelmingly conclusive, to effect that causative agent resides in drinking water, that investigation now rests upon this hypothesis. Bibliography contains 47 references.—*R. E. Thompson.*

An Investigation into the Clogging of the Filter Beds at Topchanchi Waterworks During Hot Weather. B. K. MANDAL. Indian Med. Gaz., **66**: 84–5, 1931. From Chem. Abst., **25**: 2499, May 20, 1931. Growth and decay of lower forms of vegetable life (particularly *Crenothrix*) are important factors influencing clogging of filter beds during hot weather. Increase in temperature, with acceleration in production of organic matter, causes simultaneous reduction in dissolved oxygen content and increases evolution of carbon dioxide. These conditions are favorable for growth of so-called "iron bacterium" and allied forms of life.—*R. E. Thompson.*

Water Softening: Some Properties of Certain Base-Exchange Materials. I. AUSTIN R. MARTIN. J. Soc. Chem. Ind., **49**: 389–94T, 1930; cf. C. A., **24**: 1688. From Chem. Abst., **25**: 2501, May 20, 1931. Discussion of bulk densities and volume of interstitial spaces, exchange values at various rates of flow, regeneration, mechanical disintegration and losses, and contamination of water

with silica when using various base-exchange materials. Greatest exchange value and mechanical disintegration occurred with synthetic materials.—*R. E. Thompson.*

Concentration Control of Boiler Water. HERBERT S. WHITON. Power Plant Eng., 35: 452–4, 1931. From Chem. Abst., 25: 2501, May 20, 1931. Control of concentration is necessary to avoid foaming and contamination of steam with impurities, soluble or insoluble, from boiler. In certain cases, Baumé hydrometer, specially calibrated, can be used. In others, titration of chloride, as measure of total concentration, is valuable. Conductivity methods also have a place. Frequent chemical analyses may be necessary. Concentration by-products of various methods of treatment are described. Various methods of regulating blow-down for concentration control are given.—*R. E. Thompson.*

Researches on the Protection of Concrete Against Corrosive Waters. OTTO GRAF. Zement, 19: 936–41, 970–4, 995–8, 1041–3, 1066–8, 1930. From Chem. Abst., 25: 2539, May 20, 1931. Study of corrosive action of water on concrete involves many factors in addition to concentration of salt solutions. Corrosive action increased with stirring of solutions, with coarseness of cement used in test pieces and pure gradation of cement particles, with fineness of sand used, and with quantity of mixing water, deficiency of latter being as objectionable as excess.—*R. E. Thompson.*

The Analysis of Water. V. MADĚRA. Chem. Listy, 25: 13–4, 1931. From Chem. Abst., 25: 2788, June 10, 1931. Critical review.—*R. E. Thompson.*

Concrete Coverings for Pipe Lines. J. F. HOUGH. Oil and Gas J., 29: 35, 62 and 140–141, 1931. From Chem. Abst., 25: 2553, May 20, 1931. Concrete-covered pipe was found to resist corrosion satisfactorily under most severe conditions. Best results were obtained by using less than 5 gallons of water per sack of cement. More water causes concrete to disintegrate. Pressures of 1000 pounds per square inch did not cause pressure cracks.—*R. E. Thompson.*

Ground Water in Eastern and Central Montana. EUGENE S. PERRY. Mont. Bur. Mines and Geol. Mem. No. 2, 1931. From Chem. Abst., 25: 2787, June 10, 1931. Report on occurrence of artesian water in Montana, on effect thereupon of geological structure, and on chemical composition of various types of ground water.—*R. E. Thompson.*

The Influence of pH Upon the Formation and Decomposition of the Chloro Derivatives of Ammonia. ROBERT M. CHAPIN. J. Am. Chem. Soc., 53: 912–20, 1931; cf. C. A., 23: 4158. From Chem. Abst., 25: 2657, June 10, 1931. Study of factors influencing kind and amount of products obtained by chlorination of ammonium ions. Chlorine attacks ammonium ion only after conversion into hypochlorous acid. Hydrogen ion induces formation of ammonium ion from mono- and dichloramine, particularly below certain charac-

teristic pH; resulting hypochlorous acid ($NH_2Cl + H^+ + H_2O \rightarrow NH_4^+ +$ HClO) reacts to produce more highly chlorinated derivative. Hydroxyl ion induces formation of chloride ion from nitrogen trichloride or dichloramine, particularly above characteristic pH, with nitrogen and hypochlorite ion as principal associated products. With increasing dilution, nitrous oxide, NO_2 ion and NO_3 ion also appear. Author is unable to confirm statement that some oxygen is formed by passage of chlorine into ammonia water. Cf. Chem. News, 5: 246, 1862.—*R. E. Thompson.*

The Chlorine-Binding Capacity and the Potassium Permanganate Requirement of Water and Sewage. E. Barth. Arch. Hyg., 104: 318–29, 1930. From Chem. Abst., 25: 2788, June 10, 1931. Urea and sugar increase chlorine number of boiled tap water, but do not affect chlorine requirement. Both are increased to greater degree by ferrous salts, or nitrites, than by ferric salts, or nitrates. Chlorine in concentration of 1 p.p.m. has marked bactericidal effect on tap water, bacteria requiring less chlorine than equal weight of organic substance.—*R. E. Thompson.*

Sterilizing Water. Josef Muchka. Fr. 696,342, May 31, 1930. From Chem. Abst., 25: 2792, June 10, 1931. Dechlorination by means of activated charcoal, etc., is combined with sterilization of the charcoal by submitting it during dechlorination to the transposition, or stirring, used in sand filters.—*R. E. Thompson.*

Conditioning Refinery Water. Sidney Born. Natl. Petroleum News, 23, No. 6, 52–3, 56–7; No. 7, 55, 57, 58, 60, 61, 99; No. 8, 51–3, 56, 57; No. 9, 65–8, 70; No. 10, 49–50, 52; No. 11, 70–1, 1931. From Chem. Abst., 25: 2789, June 10, 1931. Following topics are discussed: impurities found in natural waters; methods and apparatus for testing for hardness; alkalinity, causticity, acidity, salt, and total dissolved solids; benzidine method for determining sulfate; permissible limits for hardness and alkalinity in general-purpose waters; definition of pH value; chemical reactions involved in water treatment; boiler feed water; loss of heating efficiency due to scale; removal of scale-forming substances; foaming and priming; embrittlement prevention; zeolite treatment; construction and operation of lime-soda softeners; prevention of corrosion; comparison of zeolite and chemical softeners; choosing the softener; boiler compounds; water for cooling and condensing; drinking water at industrial plants and oil camps; filtration; chlorine; violet-ray and ozone treatment. —*R. E. Thompson.*

Corrosion and Metal Protection in Steam Power Plants. IV. R. Stumper. Korrosion u. Metallschutz, 7: 25–8, 1931; cf. C. A., 25: 1206. From Chem. Abst., 25: 2675, June 10, 1931. Boiler-tube failure in gas-fired furnace using hard water was investigated metallographically. Deposit of calcium sulfate was found throughout entire tube. Sections from tube at point of failure and at some distance from blow out were examined. Conclusion was that localized overheating due to impinging flame had caused failure.—*R. E. Thompson.*

The Use of Aluminum for Kitchen Utensils. VICENTE COLORBRARO. Rev. farm. (Buenos Aires), **73**: 75–87, 1931. From Chem. Abst., **25**: 2772, June 10, 1931. Quantity of aluminum dissolved from aluminum container was determined. Present knowledge of toxicity of aluminum is not sufficiently complete to permit final pronouncement of its innocuousness.—*R. E. Thompson.*

The High Toxicity of Nascent Oxygen. CARL L. HUBBS. Physiol. Zool., **3**: 441–60, 1930. From Chem. Abst., **25**: 2770, June 10, 1931. Minnows may be killed by nascent oxygen in dilution of 1 to more than 30,000,000 of water, or slightly more than 2 parts per 100,000 of their weight. Ozone, sodium hypochlorite, and hydrogen peroxide were used as sources of nascent oxygen in the experiments. Fish are irritated by dilutions of ozone too weak to detect iodometrically (doubtless less than 0.01 p.p.m.). Symptoms of poisoning are not those of asphyxiation: there is no lapping at surface. Effects of nascent oxygen, irrespective of source, are, in turn, irritation, increased and irregular respiration, loss of equilibrium, wild rolling and dashing, tetanus, and death. Death is accompanied by edematous swelling of skin. Effect of nascent oxygen is cumulative and is irreversible beyond stage of first loss of equilibrium, but is generally reversible until that stage is reached.—*R. E. Thompson.*

Aqueous Solutions of Sodium Aluminate. I. Electrical Conductivity. MATA PRASAD, S. M. MEHTA and N. G. JOSHI. J. Indian Chem. Soc., **7**: 973–80, 1930. From Chem. Abst., **25**: 2902, June 20, 1931. KOLRAUSCH method was used to measure conductivity of solutions containing various ratios of Na_2O to Al_2O_3. No conclusions can be drawn as to existence of aluminates in dilute solutions. In concentrated solution, sharp change in equivalent conductivity at ratio of 3 to 1 is interpreted as indicating formation of $Na_6Al_2O_6$.—*R. E. Thompson.*

Analysis of Water from the Odiel River (Huelva, Spain). L. BLAS. Añales soc. españ. fís. quím. **29**: 162–3, 1931. From Chem. Abst., **25**: 3103, June 20, 1931. High mortality of fish in Odiel River led to analyses which showed 0.45 p.p.m. arsenious acid and pH 4.7, quite sufficient to explain mortality and migration of fish.—*R. E. Thompson.*

Are There Gas-Forming Variants of Typhoid Bacilli? CURT SONNENSCHEIN. Z. Immunitäts, **69**: 449–63, 1931. From Chem. Abst., **25**: 3025, June 20, 1931. Critical study of claims of various workers to have observed variants of typhoid bacilli that form gas leads to conclusion that these claims are unwarranted. Organism never acquires this property by any process of regression, transformation, or dissociation. Gas formation precludes identification with *Eberthella typhi.*—*R. E. Thompson.*

The Relation Between the Fixed Residue and Electrical Conductivity in Mineral Waters. E. BOVALINI and E. VALLESI. Ann. chim. applicata, **21**: 51–75, 1931. From Chem. Abst., **25**: 3104, June 20, 1931. To approximate compositions of natural waters, a large number of solutions were prepared of following 6 types: (1) containing calcium bicarbonate alone; (2) silica and

sodium hydroxide; (3) silica, calcium bicarbonate, and sodium hydroxide; (4) silica, calcium bicarbonate, and sodium bicarbonate; (5) silica, calcium bicarbonate and sulfate, and magnesium sulfate; (6) silica, calcium bicarbonate, and various other salts. Fixed residue, r, at 180° and conductivity at 18°, K, were determined and ratio r/K was calculated. Results for r varied from 584 to 4100. Uniform values for r/K were found only in case of waters of same type, but of varying concentration, where r varied less than 20 per cent.—*R. E. Thompson.*

Protozoölogical Examination of Water. Mme. N. L. Wibaut. Chem. Weekblad, **27**: 526–9, 1930. From Chem. Abst., **25**: 3105, June 20, 1931. Tabulations of numbers of bacteria (*B. coli*) and protozoa present in previously sterilized waters at successive intervals after seedings show that in most cases both increase at first, latter much faster than former; after which, both decrease. Conclusion is drawn that protozoa can entirely eliminate bacteria in most cases. Comparative tests of number of protozoa and of bacteria present in water may be used to determine date of infection with bacteria.—*R. E. Thompson.*

Direct Method for the Quantitative Study of Bacteria in Water, and Some Considerations on the Causes Which Produce a Zone of Oxygen Minimum in Lake Glubokoje. S. I. Kuznetzov and G. S. Karzinkin. Zentr. Bakt. Parasitenk., 2 Abt., **83**: 169–74, 1931. From Chem. Abst., **25**: 3105, June 20, 1931. Diminished content of oxygen in water below the temperature leap can easily be explained by its consumption by bacteria. Greater density of these water layers precludes their rising to surface, where re-oxygenation would take place. Sharp decrease in density of water of temperature-leap layer contributes to retention of dead plankton, which favors increased development of bacteria.—*R. E. Thompson.*

Blow-Down Losses and the Means for Their Correction. A. R. Moberg. Pulp Paper Mag. Can., **31**: 495–7, 1931. From Chem. Abst., **25**: 3106, June 20, 1931. From consideration of effects of surface tension and of concentration of soluble salts and of insoluble matter, it is concluded that function of blow-down valve is reduction of concentration of soluble salts, and that reduction of concentration of suspended matter is incidental and of limited efficiency. Reduction in blow-down is dependent upon elimination of suspended matter and reduction of soluble salts in feed water.—*R. E. Thompson.*

Modern Boiler Feed Water Treatment Methods. A. E. Warner. Chemical Markets, **28**: 279–83, 1931. From Chem. Abst., **25**: 3106, June 20, 1931. Use of sodium aluminate has improved methods of water treatment. Diagrams of experimental glass boilers are included.—*R. E. Thompson.*

Determination of Iodine in Inorganic Material by Microchemical Methods. Gulbrand Lunde. Mikrochemie, **7**: 337–66, 1929. From Chem. Abst., **25**: 2937, June 20, 1931. Description of the many papers published on this subject from 1876 to present time.—*R. E. Thompson.*

Determination of the Nitrate Content of Drinking Water. Ö. Szakács. Kisérlet. Közlemények, **33**: 330–5, 1930. From Chem. Abst., **25**: 3103, June 20, 1931. Method consists in adding diphenylamine in sulfuric acid to 10 cc. water, shaking mixture in glass-stoppered bottle, cooling quickly, and within about 5 minutes comparing with standard solution made of basic copper carbonate, potassium dichromate, and rosolic acid equivalent to 60 milligrams N_2O_5 per liter and diluted to desired concentration.—*R. E. Thompson.*

Corrosion Due to Hydrodynamics. R. Auerbach. A. E. G. Mitteil., 1931, 15–6. From Chem. Abst., **25**: 3253, July 10, 1931. Years ago Helmholtz showed that, although there is no potential difference between 2 identical electrodes when both are at rest, a potential difference is at once noticeable when either electrode, or either catholyte, or anolyte, is agitated. Author finds that upon passing distilled water, or salt solution, simultaneously through 2 iron capillaries (one of larger bore than the other) no difference in potential is observed when flow through both is same. However, as soon as flow through one is different from that through other, a decided potential difference is recorded. It seems plausible, therefore, that corrosion of boiler tubes may at times be due to differences in velocity of flow of water over different points, or areas, of tubes.—*R. E. Thompson.*

Dependence of Base-Exchange in Permutites on the Nature of the Anions. E. Ungerer. Z. Pflanzenernähr., Düngung, u. Bodenk., **18A**, 342–6, 1930; cf. C. A., **24**: 5249. From Chem. Abst., **25**: 3261, July 10, 1931. Exchange of bases between calcium permutite and chlorides and sulfates of lithium, sodium, potassium, and magnesium is examined. In all cases, displacement of calcium from permutit is greater with sulfates than with corresponding chlorides, divergence increasing with concentration of displacing ion. Effect is ascribed to dehydrating action of the highly hydrated sulfate ion.—*R. E. Thompson.*

Applicability of Chemical Reactions to Microanalysis. I. Colorimetric Micro-Determination of Metals with 8-Hydroxyquinoline. R. Berg, W. Wolker and E. Skopp. Mikrochem., Emich Festschr., 1930, 18–22. From Chem. Abst., **25**: 3263, July 10, 1931. Magnesium is precipitated with 8-hydroxyquinoline in presence of ammonium chloride; after heating for 10 minutes on water bath, precipitate is removed by centrifuging and dissolved in normal hydrochloric acid. Sodium hydroxide solution and special reagent are added, and after heating at 80° for 30 minutes color is compared with that given by known amount of magnesium. Reagent is prepared by dissolving 100 grams of sodium tungstate, 20 grams of phosphomolydic acid, and 50 cc. 85 percent phosphoric acid in water, boiling for 2 hours, and diluting to liter. Method yields good results in presence of 40 times the quantity of calcium, but excess of 8-hydroxyquinoline must be used to allow for formation in solution of calcium compound. **III. Gravimetric Microdetermination of Copper and Titanium with 5,7-Dibromo-8-hydroxyquinoline.** R. Berg and H. Küstenmacher. Ibid., 26–8. 5,7-Dibromo-8-hydroxyquinoline will detect 1 part copper, or titanium, in 10,000,000, or 2 parts of iron in 10,000,000. An 0.1 percent solution of reagent in acetone is added to slightly acid solution containing the

metal and about 30 percent acetone, at 50°; after boiling for from 3 to 5 minutes, precipitate is removed and washed with warm, slightly acid 30 percent solution of acetone and dried at 110–120°.—*R. E. Thompson.*

Application of Microchemical Methods to the Determination of Traces of Substances. R. Lucas, F. Grassner and E. Neukirch. Mikrochem., Emich Festschr., 1930, 197–214. From Chem. Abst., **25**: 3264, July 10, 1931. Microelectrometric method of Pregl is suitable for determining small quantities of copper, but where traces only (1 microgram) are concerned, the cathodically deposited metal is dissolved in nitric acid and precipitated as potassium lead copper nitrite by evaporation of solution with lead acetate and treatment of residue with solution of potassium nitrite, ammonium acetate, and acetic acid; product is compared with that given by known amount of copper. Quantities of lead down to 25 micrograms, even at very high dilutions, may be determined by precipitation with copper as sulfide, solution of precipitate in nitric acid, and deposition as lead peroxide on stationary anode; precipitate is titrated with potassium iodide and 0.01 normal sodium thiosulfate.—*R. E. Thompson.*

Detection of Traces. F. Feigl. Mikrochem., Emich Festschr., 1930, 125–34. From Chem. Abst., **25**: 3264, July 10, 1931. Traces of hydrogen sulfide in water may be removed by shaking with mercury, and presence of sulfur may then be demonstrated by evolution of nitrogen when mercury is covered with acidified solution of sodium azide and iodine; 0.05 microgram of hydrogen sulfide in 10 cc. of water may be detected in this manner.—*R. E. Thompson.*

Colorimetric Method for the Detection and Estimation of Small Quantities of Lead. Edward W. Krans and J. B. Ficklen. J. Ind. Hyg., **13**: 140–3, 1931. From Chem. Abst., **25**: 3266, July 10, 1931. Following method is suitable for determining 0.01–0.2 milligram of lead. Evaporate the nitric acid solution to from 2 to 4 cc., cool, and make alkaline to phenolphthalein, adding 5 drops 25 per cent sodium hydroxide in excess. Make slightly acid with acetic acid and precipitate lead chromate by adding 1 cc. 1 percent potassium chromate solution. Allow to stand overnight at about 20°. Heat nearly to boiling for 20 minutes and filter. Wash precipitate with hot water, dissolve in 15 cc. 4-normal hydrochloric acid in 200-cc. measuring flask, add 2 cc. 1 percent solution of *s*-diphenylcarbazide in glacial acetic acid and make up to mark with water. Compare pink color in colorimeter with known standards of potassium dichromate solution treated in same way with organic reagent. Presence of aluminum, arsenic, barium, bismuth, cadmium, calcium, cobalt, copper, iron, magnesium, manganese, mercury, nickel, silver, or tin does not interfere.—*R. E. Thompson.*

Microdetermination of Thallium and Lead. L. Moser and W. Reif. Mikrochem., Emich Festschr., 1930, 215–8. From Chem. Abst., **25**: 3269, July 10, 1931. Lead is precipitated by diammonium phosphate from hot, slightly alkaline solution containing sulfosalicylic acid. Precipitate should be washed with ammonia solution and dried at 150°.—*R. E. Thompson.*

Application of the Weining and Bowen Method for the Determination of Dissolved Oxygen. G. BATTA and N. ANDRAULT DE LANGERON. Chimie & industrie, Special No., 179–86, March, 1931. From Chem. Abst., 25: 3270, July 10, 1931. WEINING and BOWEN method (C. A., 19: 1674) is applicable to waters of all origins and to aqueous solutions of electrolytes. Reducing substances do not interfere, but oxidizing compounds and high concentrations of electrolytes cause precipitation of indicator. Method is simple, practical, rapid, and accurate to at least 0.5 p.p.m. In absence of oxidizing and reducing matter, it gives results agreeing to within 0.5 p.p.m. with those obtained by WINKLER method (C. A., 9: 674). Protective action of chloroform is much greater on indicator solution than on either starch or gelatin, and it does not affect determination of dissolved oxygen with sodium hyposulfite. Indigo carmine (chemically pure), from 4.25 to 4.50 grams per liter, is recommended as indicator; it is prepared by dissolving in water on water bath and is kept in contact with chloroform, in glass-stoppered bottle, protected from light. Titration should be carried out in solution neutral to phenolphthalein; low results are obtained in acid solution and high results in alkaline solution. Titration should be performed as rapidly as possible to avoid diffusion of atmospheric oxygen through protective layer of kerosene (WEINING and BOWEN) or xylene (adopted by BATTA and DE LANGERON), and care should be taken to avoid introduction of oxygen when agitating solution during titration. The indicator solution of indigo carmine is suggested as primary standard for standardizing the hyposulfite solution instead of water saturated with air, as suggested by WEINING and BOWEN. The hyposulfite solution should be prepared about 24 hours before use; it can then be used for from 12 to 14 days, but should be standardized for each set of determinations.—*R. E. Thompson.*

A New Rapid Method of Making Corrosion Tests. L. W. HAASE. Chem. Fabrik, 1931: 169–70, 184–5. From Chem. Abst., 25: 3299, July 10, 1931. Description of apparatus for producing constant flow of water through vessels containing the metals under test. The hook-up of the electric indicator is illustrated. Rate of flow has great influence on rate of corrosion and on protective crust formation. Test may be made in from 24 to 72 hours.—*R. E. Thompson.*

A True Measure of the Aggressivity of Natural Waters. J. TILLMANS and P. HIRSCH. Z. anorg. allgem. Chem., 197: 182–8, 1931; cf. C. A., 24: 1688. From Chem. Abst., 25: 3417, July 10, 1931. Polemical with ORLOW (cf. C. A., 24: 4564). ORLOW's aggressive H-ion concentration is shown not to be true measure of aggressivity of natural waters.—*R. E. Thompson.*

Effect of Heating and Boiling on the Temporary Hardness of Water. A. V. FILOSOFOV. Zhur. Prikladnoĭ Khim., 3: 1055–61, 1930. From Chem. Abst., 25: 3418, July 10, 1931. Evolution of carbon dioxide begins at 55°. On heating above 55° to boiling point rate of decrease in hardness stays constant and, if hardness, x, is expressed in German degrees and time, t, in seconds, value of dx/dt is 0.00535. On boiling, decrease in hardness is rapid at first, but becomes negligible after from 30 to 35 minutes. It is shown that $dx/d\theta = 1/\theta . \ln b$,

where θ = time of boiling and, if same units are used as above, b = 1.50 for from 120 to 300 seconds' boiling and 1.56, for more than 300 seconds. Practical application of equations is explained.—*R. E. Thompson.*

A New Automatically Operating Oxygen-Measuring Apparatus. KARL HOFER. Die Wärme, 54: 236–7, 1931. From Chem. Abst., 25: 3418, July 10, 1931. Method of determining oxygen content of boiler feed water automatically and continuously is described. Sample of feed water is filtered, cooled, and atomized. Stream of hydrogen, generated electrolytically, carries any gases liberated from water through thermal conductivity cell. Oxygen content is determined by comparing conductivity of mixed gas with that of pure hydrogen. Comparison cells are connected in Wheatstone bridge circuit and oxygen content is recorded on strip chart in p.p.m. Results with one installation compared well with chemical analyses, but showed time lag of about 10 minutes.—*R. E. Thompson.*

Commercial Softening of Water by Means of Zeolites. P. PATIN. Chimie & industrie, Special No., 234–41, March, 1931. From Chem. Abst., 25: 3418, July 10, 1931. Design and operation discussed.—*R. E. Thompson.*

NEW BOOKS

Vom Wasser; Ein Jahrbuch für Wasserchemie und Wassereinigungstechnik, VII Band: 1933. 310 pp. Verlag Chemie, G.M.B.H., Berlin W. 10. **Water and the Chemist.** H. BACH. 11–21. Importance of water and necessity of chemical and bacteriological examination are stressed. Dissolved solids are consideration for cleansing uses; small zeolite plants are much used, e.g. in hotels; but precipitating chemicals are generally used in water works practice. Important factors in iron corrosion are free carbon dioxide, dissolved oxygen, and dissolved salts. In textile industries hardness, silicate, chlorides, humic acid, and animal and plant life are injurious; in heavy industries, although quantity is important, purity is also necessary e.g. in cooling and condenser water. Influence of dissolved matter in water for brewing and mineral water manufacture is noted. In boiler practice, chemist is interested in conditioning water to lengthen life of boiler. Swimming bath water should be purified from hygienic and aesthetic standpoints. Detrimental effect upon health and industry of insufficient sewage treatment and need for improvement and control of treatment by chemists is stressed; disposal is more difficult in Germany than in Holland or England with their numerous short rivers and canals. **"Microforces" in Water and Their Application to Water Purification.** J. WIGGER. 22–49. This paper was inspired by work of F. HANNAN, (THIS JOURNAL, 10: 1923, 1035–1050). Capillarity, surface tension, curvature of water-surface etc. are dealt with mathematically and Poiseuille law of liquid stream motion through tubes is considered. Reference is made to production of oil films at water surfaces and phenomena relating thereto. Two methods of producing "LIEBREICH-zone" are given. In production of liquid films and foams, degree of film strength depends on amount of substance in solution, surface tension, and viscosity. Corrosion is also studied, it is most common at junction of

solid, liquid and gas phases, and study of microforces is important in this connection. **Investigation of the Central Water-Supply System of the City of Vienna.** V. Gegenbauer. 50–73. Geological formation of Alpine gathering grounds and historical survey of transportation of water long distances are given. Bacteriological examinations disproved assertion that imperfectly filtered water was being supplied, but revealed necessity of systematic observations of fluctuation in conditions of supply, using total bacterial count as index of purity. Purification and chlorination are discussed and statement made that demand of public for palatable water must be met. **Removal of Bacteria from Water by Electro-Katadyn Process.** G. A. Krause. 74–89. First katadyn purification methods used quartz contacts impregnated with finely divided silver. Author describes with five illustrations new electro-katadyn apparatus. Silver electrodes pass weak electric current through water, forming silver ions which exercise bactericidal effect. Units manufactured take up little space, are cheap, and have been used for various purposes, e.g. purification of Heidelberg water, sterilization of water at Frankfort Baths, and preparation of bacteria-free ice at Dresden. Bibliography containing references to 36 articles on Katadyn process is appended. **Sterilization of Water at the Surface of Crystalline Metals.** Van der Leeden. 90–103. Metals in "Zement," or precipitated, form have germicidal action and article describes experiments with silver and with copper. "Zement"-copper, which has composition copper 80–85 percent, ferric oxide 5–10 percent, aluminum oxide 5–10 percent, added to water in powder form, effected considerable reduction in bacterial content. When tested in combination with chlorine, process proved successful for dechlorination. In **discussion,** work of J. R. Baylis, of Chicago, was stressed and table giving results of his experiments on dechlorination with copper oxide is reproduced. **A Contribution to the Knowledge of the Reactivity of Carbon Dioxide in Water.** F. C. Gaisser. 104–116. Experimental study shows that decrease of alkalinity in water is of great importance and has not been sufficiently studied. Behavior of marble varies with different waters and it is difficult to determine end-point when titrating marble solutions with acid. Calculation of aggressive carbon dioxide as difference between "zugehörige" and free carbon dioxide is accurate only for pure water and not for salt solutions or mineral waters. Each water must be studied in light of its own chemical and physical properties and when considering spring and mineral waters it must be remembered that frequently salts are not present in simple form, nor as electrolytes, but as complex salts. **The Cause and Prevention of Corrosion of Cast Iron Pipe in Groningen Soils.** C. M. Wichers. 117–132. Pipes and surrounding soil were examined. Metallographic analysis showed that condition of cast iron had little influence on this particular corrosion; none of pipes were free from graphite and uncorroded parts contained much graphite. Corrosion was caused by loose soil around pipes, through which air and water could percolate. Hydrogen ion concentration of soil was high, hydrogen sulphide and sulphates were present; but calcium carbonate was absent. Prevention of corrosion is effected by covering pipes with thick layer of clay, thus preventing circulation of gases and water, and mixing milk of lime with soil. **Removal of Colloidal Iron from Water.** G. Bode. 133–137. Although iron normally occurs in water in true solution, as bicarbonate,

it may also be present in colloidal form (from peat, brown coal, etc.) in organic combination. Such iron, as well as manganese, can be more or less successfully removed by strong aëration, spraying through nozzles in wooden tower through which a blast of air is delivered and filtering in a Bollman filter containing two-meter layer of gravel. Iron-free water was obtained by treating such aërated water with experimentally determined amount of trisodium phosphate. Colloidal iron can only be determined by thiocyanate reaction after water has first been made alkaline and then immediately acidified with nitric acid. Colorimetric method using $\alpha\alpha'$-dipyridyl is recommended and described, as being of special value in water analysis. **Effect of the Decomposition of Natural Organic Impurities on the Quality of Surface Water.** H. HAUPT. 138–152. Water from lakes and impounding reservoirs contaminated by leaves are often yellow in color due to tannin and dissolved organic matter. Oak leaves color water deeply owing to copious dye content and large amount of tannin. Beech leaves give about one-eighth as much color as oak, having a less soluble tannin and dyestuff. Pine and fir needles seldom reach reservoirs, except by streams, and coloring effects are slight. Laboratory experiments showed that removal of tannin and coloring matter was not always possible with usual coagulation methods even at reduced pH. Fir trees are recommended for planting around reservoirs, and the bottom should be free from humus. **Weathering of Chalk Residues in the Saale Beyond Bernburg.** E. NOLTE. 153–155. Describes weathering of large mass of solvay residues, forming a dam between two rivers. **The Development of Boiler Feed Water Treatment.** A. SPLITTGERBER. 156–14. Historical survey of boiler water treatment. Recently treatment has become more complicated, involving removal of oxygen and chemical control so that permanent hardness averages one degree. Concentration of boiler water should not exceed 80 times that of feed water. Highest salt content recommended in boiler with more than 90 percent condensate is 0.6° Be and alkalinity, 1.25 grams per litre, expressed as soda. **Silicic Acid in Water and Its Removal.** H. A. REIMERS. 175–184. Silicate content of water is important in some industries, e.g. artificial silk, and in high-pressure boiler work, owing to hard scale formation of calcium and magnesium silicates and calcium sulphate. Zinc salts or zincates were found, at suitable pH to remove silicic acid quantitatively as a complex zinc silicate. Works process for removing silicic acid depends on zinc sulfate, or phosphate; it is usually combined with softening process when flocculation chemicals are used to remove turbidity. Scheme for removal of silicates from feed water combined with lime-soda and zeolite softening is given. **Analysis of Boiler Feed Water.** G. AMMER and H. SCHMITZ. 185–196. Original form of BLACHER's method for sulfates is recommended; i.e. removal of sulfate with excess of tenth normal barium chloride and titration without filtration of excess barium with tenth normal potassium palmitate. In presence of phosphate, this must first be removed by shaking in acid solution with tenth normal calcium chloride, neutralizing to phenophthalein, and boiling. Sulfate can also be determined by adding excess barium chloride and shaking excess with soap solution in shaking cylinder. **Softening with Lime-Barium-Carbonate Process and with Barium Hydroxide.** J. LEICK. 197–205. Double decomposition of calcium and magnesium sulfates by barium carbonate is incomplete, but is

helped by free carbon dioxide, by excess barium carbonate, and by slightly increased temperature. Reaction time is 45 minutes; but barium carbonate does not react with calcium and magnesium chlorides. Lime must be added after barium and softening can be improved by secondary treatment with soda. Barium hydroxide combined with sodium triphosphate produces feed water with least residual hardness and least salt content of any chemically purified water. If raw water is free from chloride, product almost equals distilled water. **Operating Results of the Municipal Sewage Plant. Nürnberg.** E. Merkel. 206–232. **Plain Settling Tanks for Sewage Treatment Considered from the Chemical Standpoint.** W. Husmann. 233–238. **Copper and Biological Treatment of Sewage.** F. Sierp and F. Fransemeier. 239–258. **Experience in the Treatment of Fermentable Industrial Wastes.** G. Bode. 259–271. Describes cases of prevention of stream pollution by industrial effluents. In yeast factory, wastes are evaporated with waste heat from distillation of alcohol from wort, and concentrated residue, either burnt for potash, or sold as fertiliser; operating costs are more than covered. Works distilling alcohol from molasses concentrates wort and works residue up into potash. Other wastes are discharged into shallow tanks and aërated, whereby oxidizing bacteria break down organic substances and render wastes odorless and harmless for discharge into stream. **Results of an Investigation of the Chemical and Biological Effects of Potash Wastes on Fisheries.** G. Ebeling. 272–288. Fish, e.g. carp and perch, were placed in potash waste liquors of various known strengths. Wastes are rarely harmful in dilutions obtaining in practice. Potassium chloride is considerably more toxic than either sodium or magnesium chloride, but calcium chloride lessens toxicity of potassium salt; therefore potassium:calcium ratio is important. **Laboratory Experiments on the Fermentation of Sewage Mud with "Thermophilic" Organisms.** H. Bach. 289–310.—*W. G. Carey.*

Sixty-Seventh Annual Report of the Commissioners of Water Works in the City of Erie, Pa., for Year Ending December 31, 1933. 71 pp. This report consists almost entirely of detailed tabulations of operating and financial statistics, to which is appended brief description of works and schedule of water rates. Daily average consumption was 19.77 million gallons, the per capita figure being 164.78 gallons (population 120,000), or, exclusive of metered industrial and commercial use, 102.85 gallons. Cost of collecting, purifying, and delivering water was $37.35 per million gallons. Number of gallons pumped per pound of coal used averaged 380.67. Statement of profit and loss shows operating surplus of $35,597.18; this amount, together with $27,025.29 withdrawn from accumulated surplus, was required to meet bond expenses. Water to value of $59,557.92 was supplied without cost to city for municipal purposes. Plant operating data show, for the Chestnut Street and West filter plants, respectively, following average amounts of chemicals and wash water used: alum, 0.254 and 0.220 grain per gallon; chlorine, 1.71 and 1.65 pounds per million gallons; ammonia, 1.05 pounds per million gallons (Chestnut Street only); and wash water, 2.6 and 1.38 per cent of water filtered. Analytical data include monthly average bacterial counts, turbidity, alkalinity, and color of raw and filtered waters, average temperature, and results of *B. coli* tests. Fil-

ter effluents of both plants consistently gave negative *B. coli* results (10 and 1 cc.) throughout the year.—*R. E. Thompson.*

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Manual of Electric Arc Welding. E. H. HUBERT. New York and London: McGraw-Hill Book Co. Cloth; 6 x 9 inches; pp. 163. $2. Reviewed in Eng. News-Rec., **108**: 737, May 19, 1932.—*R. E. Thompson.*

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